

Galloway (B. T.)

AUTHOR'S EDITION.

FROM THE ANNUAL REPORT OF THE DEPARTMENT OF
AGRICULTURE FOR THE YEAR 1888.

REPORT

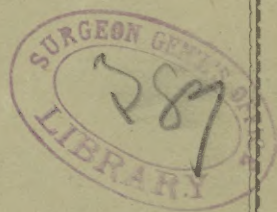
OF

THE CHIEF OF THE SECTION OF VEGETABLE PATHOLOGY,

B. T. GALLOWAY,

FOR

THE YEAR 1888.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1889.

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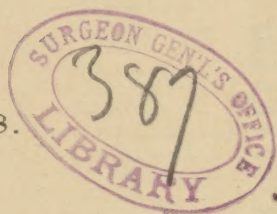
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TABLE OF CONTENTS.

	Page.
A.—EXPERIMENTS IN THE TREATMENT OF VINE DISEASES.....	326
B.—NECESSITY FOR MORE EXTENDED FIELD WORK.....	335
C.—MISCELLANEOUS SUBJECTS.....	336
1. THE DOWNY MILDEW OF THE POTATO.....	337
I. General remarks.....	337
II. Botanical characters.....	337
III. Conditions favoring the disease.....	338
IV. Treatment.....	338
2. NOTES ON BLACK-ROT OF THE TOMATO.....	339
I. General observations.....	339
II. External characters.....	340
III. Losses, conditions known or supposed to favor the disease, etc.....	340
IV. Conclusions as to the cause of black-rot.....	341
V. Microscopical characters of the Macrosporium.....	342
Mycelium.....	342
Spores.....	342
VI. Microscopic characters of the Fusarium.....	342
Mycelium.....	342
Macroconidia.....	343
Microconidia.....	343
VII. Life history.....	343
VIII. Treatment.....	345
IX. Report of Dr. H. S. Bowers.....	345
3. A DISEASE OF THE TOMATO.....	347
I. General observations.....	347
II. Botanical characters.....	348
4. BROWN ROT OF THE CHERRY.....	349
I. General observations.....	349
II. External characters.....	350
On the flowers.....	350
On the leaves.....	350
On the fruit.....	350
III. Botanical characters.....	350
Mycelium.....	350
Spores.....	351
IV. Treatment.....	352
5. POWDERY MILDEW OF THE CHERRY.....	352
I. General remarks.....	352
Host plants and distribution.....	353
II. External characters.....	354
III. Botanical characters.....	354
IV. Conditions favoring the development of the fungus.....	356
V. Treatment.....	356
VI. Bibliography.....	357
6. LEAF BLIGHT AND CRACKING OF THE PEAR.....	357
I. General observations.....	357
Effects and losses.....	357
Hosts.....	358
Geographical distribution.....	358
History.....	359
II. External characters.....	359
III. Microscopical characters.....	360
IV. Treatment.....	362
V. Bibliography.....	364

	Page.
C.—MISCELLANEOUS SUBJECTS—Continued.	
7. LEAF-SPOT OF THE ROSE.....	364
I. General observations.....	364
II. External characters.....	365
III. Microscopic characters.....	365
IV. Treatment.....	365
8. PLUM-POCKETS:	
I. General observations, history.....	366
II. External characters.....	367
III. Botanical characters.....	368
IV. Bibliography.....	369
9. APPLE-RUSTS.....	370
I. General observations.....	370
II. The genus <i>Gymnosporangium</i>	372
History of the genus.....	372
Characteristics of the species.....	372
Injury to the hosts.....	373
III. The <i>Roestelia</i> forms.....	374
IV. <i>Gymnosporangium macropus</i>	376
History.....	376
Geographical distribution.....	376
External characters.....	376
Conditions favoring the development of the fungus.....	377
V. <i>Roestelia</i> on apples.....	378
VI. Treatment.....	379
VII. Bibliography.....	381
10. SEPTOSPORIUM ON GRAPE LEAVES.....	381
I. General observations.....	381
II. Botanical characters.....	382
11. LEAF-SPOT DISEASE OF THE MAPLE.....	383
I. General observations, history, etc.....	383
Hosts.....	383
Geographical distribution.....	383
II. External characters.....	384
III. Botanical characters.....	385
IV. Treatment.....	386
V. Bibliography.....	386
12. A DISEASE OF THE SYCAMORE.....	387
I. General observations.....	387
Geographical distribution.....	387
Hosts.....	387
History.....	387
II. Botanical characters.....	388
III. Treatment.....	389
IV. Bibliography.....	389
13. THE LEAF-RUST OF COTTONWOODS.....	390
I. General observations.....	390
II. Effects on host.....	390
III. Hosts and geographical distribution.....	391
IV. Botanical characters.....	391
V. Treatment.....	392
VI. Bibliography.....	392
14. REPORT ON PEACH YELLOWS.....	393
I. Trees affected.....	393
II. When and where discovered.....	393
III. Former severity.....	393
IV. Present distribution.....	393
V. Present severity.....	393
VI. Symptoms.....	394
VII. Diseases mistaken for yellows.....	395
VIII. Cause of yellows.....	395
IX. Remedies.....	398
X. On replanting, etc.....	398
15. ADDITIONAL NOTES ON CELERY-LEAF BLIGHT.....	398

REPORT OF THE SECTION OF VEGETABLE PATHOLOGY.

SIR: Having been appointed Chief of the Section of Vegetable Pathology on the 1st of November, 1888, I have the honor to present herewith my first report.

During the past year, and since the publication of the Annual Report for 1887, the Section has issued four bulletins as follows:

Bulletin No. 5 on the experiments made in 1887 in the treatment of the downy mildew and black-rot of the grape-vine, together with a chapter on apparatus for applying remedies for these diseases. This bulletin was issued early in May, 1888, and contains 113 pages, and 24 illustrations. The first 36 pages embody the reports of four special agents, who, under the direction of the Section, and with your sanction, conducted a series of experiments at Vineland, N. J.; Charlottesville, Va.; Neosho, Mo.; and Denison, Tex. Part II of the Bulletin contains the reports of more than 200 grape-growers who experimented with the sulphate of copper remedies, while Part III embodies the results of observations made in 1887 in the treatment of the downy mildew in France.

Bulletin No. 7 on the history and progress of black-rot of grapes in America is for the most part a translation of a paper by Viala & Ravaz, of Montpellier, France,* and embodies the results of observations made in this country in 1887 by P. Viala and F. L. Scribner.

Bulletin No. 8 relating to some of the practical work of the Section, including papers on potato-scab, foot-rot of the orange, extracts from correspondence, etc., was issued as a joint publication with one of a similar nature prepared by Dr. George Vasey, Chief of the Botanical Division.

Bulletin No. 9 on peach yellows, embodying the results of investigations made by Erwin F. Smith, a special agent appointed for this work, contains 200 pages, 9 colored maps, 6 lithographic and 37 photo-engraved plates. A short abstract of this bulletin will be found in the accompanying pages of this report.

The correspondence of the Section is constantly increasing, and as it is a most important means of disseminating useful information every effort is made to give it the attention it deserves.

During the year many new and valuable additions have been made to the herbarium, and the number of permanent microscopic mounts of fungi has also been materially increased.

Since the middle of July Mr. F. W. Anderson, a special agent of the Section, has been at work in Montana collecting specimens and

* Extrait du Progress Agricole et Viticole, Sept., 1888.

making observations on the fungi of that region. In this work particular attention has been given to the fungi of grasses, and arrangements have been made for distributing these among the various Agricultural Colleges and Experiment Stations.

The following report, prepared at my request by Mr. Anderson, shows the nature of the work in which he is engaged.

REPORT OF F. W. ANDERSON.

From the middle of July, 1888, to the close of the collecting season, I was actively engaged in collecting specimens of phanerogams and fungi for the Botanical Division, and during that time several important parts of the Territory were visited. More special attention was given to the parasitic fungi than to any other part of the work. In fact, enough has been done in this line to justify the publication of a "Preliminary List of the Parasitic Fungi of Montana."

In the prosecution of this work it has been my constant effort to learn as much as possible of the economic importance of every species found—the relation borne by the fungus to its host and by the host to the lower animals and to man. In this way I have been able to make at least a few notes worthy of careful consideration by Experiment Station authorities as well as by those who make farming their occupation.

In the list of fungi, which at this writing is not yet completed, there will be over 200 species enumerated, nearly a dozen of which are new to science. One I would call special attention to here is a new *Ustilago*, or smut, on *Muhlenbergia*, called by Messrs. Ellis and Holway, who described it in the Journal of Mycology, *Ustilago Montaniensis*. This fungus is very common here and causes most wretched changes in the panicles of the host. As soon as the grass is old enough to develop the first head or spike, the fungus has already matured; and as the grass shoots up, developing its numerous spikes, each one in an affected plant will be found completely filled by the black-looking spores of the *Ustilago*. It would seem from this that the spores grow within the tissue of the host while it is very young, and in their own development keep pace with that of the host.

With the list will be figures of the new species and as full notes as I have been able to collect about each. In Montana a collector of parasitic fungi can not fail to be impressed by the great comparative number of species representing the *Uredineae*, or rusts. They are to be found everywhere in one stage or another; on the tops of the highest mountains; on the driest of plains and in the most moist of valleys. Fortunately for growing vegetation, most of the species are apparently harmless, causing no injury to living tissue removed from actual contact with them.

In concluding this brief note I would express my thanks to my friend, the Rev. F. D. Kelsey, of Helena, Mont., for the many valuable notes and specimens of fungi and other plants he has sent me from time to time as well as for his open hospitality and the freedom of his valuable collection of Montana plants, whenever it has been my good fortune to work in his locality.

F. W. ANDERSON,
Special Agent.

B. T. GALLOWAY,
Chief of Section.

A.—EXPERIMENTS IN THE TREATMENT OF GRAPE-VINE DISEASES MADE IN 1888.

[Extracts from reports of special agents and others.]

As heretofore extensive experiments in the treatment of the fungous diseases of the vine have been conducted by special agents located in New Jersey, Virginia, and Missouri, as well as by private individuals in nearly every State in the Union. The information acquired through these will form the basis of a special report soon to be published. As the edition of this bulletin will be comparatively limited, the following extracts from a few of the more important reports are here given.

On May 5, 1888, the following letter was sent to each of the special agents, and at the same time a circular, which is given in full below, was distributed among grape-growers with the request that they follow the instructions contained therein.

I.—LETTER OF INSTRUCTION TO AGENTS.

DEAR SIR: I send herewith several formulas to be used in the treatment of vine diseases. I desire the experiments to be conducted in a manner similar to those of last year, of course making such changes in detail as former experience has made necessary.

The remedies to be experimented with are eau celeste, Bordeaux mixture, and sulphatine.

1. EAU CELESTE, AUDOYNAUD PROCESS:

Dissolve 1 pound of sulphate of copper in 2 gallons of hot water; when completely dissolved and the water has cooled, add $1\frac{1}{2}$ pints of commercial ammonia (strength 22° Baume); when ready to use dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden, earthen, or glass vessel.

2. EAU CELESTE, MODIFIED FORMULA:

Sulphate of copper.....	pounds..	2
Carbonate of soda.....	do....	2 $\frac{1}{2}$
Ammonia (22° Baume).....	pints..	1 $\frac{1}{2}$
Water.....	gallons..	22

Dissolve the sulphate of copper in 2 gallons of hot water, in another vessel dissolve the carbonate of soda in a similar manner; mix the two solutions, and when all chemical reaction has ceased add the ammonia; then dilute to 22 gallons.

3. BORDEAUX MIXTURE:

Sulphate of copper.....	pounds..	6
Lime.....	do....	4
Water.....	gallons..	22

Dissolve the copper in 16 gallons of water; in another vessel slake the lime in 6 gallons of water; when the latter mixture has cooled pour it slowly into the copper solution, care being taken to mix the fluids thoroughly by constant stirring.

4. SULPHATINE, THE ESTÉVE PROCESS:

Mix 2 pounds of anhydrous sulphate of copper with 20 pounds of flowers of sulphur and 2 pounds of air-slaked lime. The proportions may be varied.

Respectfully,

NORMAN J. COLMAN,
Commissioner of Agriculture.

II.—CIRCULAR DISTRIBUTED AMONG GRAPE-GROWERS.

[United States Department of Agriculture. Section of Vegetable Pathology.]

Treatment of the downy mildew and black-rot of the grape.

To the Vineyardists of the Country:

The results of experiments in 1887 have fully demonstrated the value of sulphate of copper (blue-stone) over all other remedies in combating the mildew, and the results of many chemical analyses of the fruit and parts of vines treated with copper compounds have clearly shown that there is no danger to health attending their application. The only precaution advised is not to apply them near the time (within fifteen days) of the vintage.

In their employment the fact must be kept in mind that their action is only preventive, therefore their application should be made early in the season, from the latter part of May to the end of June. Subsequent applications act only in so far as they serve to check the spread of the disease. The amount of the fluid compounds required to treat an acre of vines will depend largely upon the kind of pump and spraying nozzle used to supply them, and upon the extent of growth of the vines themselves; the amount may vary from 20 to 35 gallons.

The following are the formulæ of the remedies which so far have given the best results. An account of the results of trials you may make with one or more of them is earnestly desired, and a blank form for making up a report for the use of the Department in future publications will be sent you upon the receipt of the addressed postal card inclosed herewith.

Liquid remedies.

(1) *Simple solution of sulphate of copper.*—Dissolve 1 pound of sulphate of copper in 25 gallons of water. Spray the vines with a convenient force-pump having a nozzle of fine aperture. Less lasting in its effects than the next, as it is easily washed off by rains.

(2) *Eau celeste, blue-water (the Audoynaud process).*—Dissolve 1 pound of sulphate of copper in 3 or 4 gallons of warm water; when completely dissolved and the water has cooled, add 1 pint of liquid ammonia; then dilute to 22 gallons. The concentrated liquid should be kept in a keg or some wooden vessel and diluted when required for use. Apply the same as in case of simple solutions.

(3) *Eau celeste, modified formula:*

Sulphate of copper	pounds..	2
Carbonate of soda	do....	2½
Ammonia (22° Baume)	pints..	1½
Water	gallons..	22

Dissolve the sulphate of copper in 2 gallons of hot water; in another vessel dissolve the carbonate of soda in a similar manner; mix the two solutions, and when all chemical reaction has ceased add the ammonia; then dilute to 22 gallons.

(4) *Bordeaux mixture.*—Dissolve 6 pounds of sulphate of copper in 16 gallons of water; in another vessel slake 4 pounds of lime in 6 gallons of water. When the latter mixture has cooled pour it slowly into the copper solution, care being taken to mix the fluids thoroughly by constant stirring. Well made pumps with specially constructed nozzles are required for the application of this compound. The Vermorel apparatus and the Eureka sprayer are well adapted for vineyard use, and are especially constructed for applying the various liquid preparations containing sulphate of copper.

Powders.

(5) *Sulphatine, the Estève process.*—Mix 2 pounds of anhydrous sulphate of copper with 20 pounds of flowers of sulphur and 2 pounds of air-slaked lime. The proportions may be varied.

(6) *David's powder.*—Dissolve 4 pounds of sulphate of copper in the least possible amount of hot water, and slake 16 pounds of lime with the smallest quantity of water required. When the copper solution and slaked lime are completely cooled mix them together thoroughly; let the compound dry in the sun; crush and sift. Apply with a sulphuring bellows furnished with an outside receptacle for the powder. The copper coming in contact with the leather will soon destroy it.

Both these powders ought to be procured from the manufacturer prepared ready for use.

III.—EXPERIMENTS AT VINELAND, N. J.

The experiments were conducted at this place by Col. A. W. Pearson, and the vines treated were of the Concord variety. The applications were made with the Eureka sprayer and the Riley cyclone nozzle, May 29, June 14, June 21, July 2, July 11, and August 8. Black-rot appeared on the leaves of the untreated vines on June 2 and on the fruit of the same vines June 27. Rain and fog were frequent during July, and by the last of the month all Concord grapes unprotected were totally destroyed. There was also considerable rot on the treated vines. Throughout the season the rot continued, only ceasing when there were no more grapes to rot. Downy mildew (*Peronospora viticola*) first appeared epidemically about August 10, but as the season was cool and moist it occasioned no serious injury.

Concerning the efficacy of the remedies for black-rot Colonel Pearson concludes his report as follows:

On the untreated vines the grapes are almost totally destroyed. One or two sound berries may be found remaining on a few clusters, but at least nine-tenths of

the bunches show only a mass of dried and shriveled victims of the disease. On all the vines treated with the remedies prevention of rot is perceptible, but on none of them is it strikingly so, except on those sprayed with the Bordeaux mixture. Here, the treated rows have many nearly perfect clusters, which show but one or two rotted berries each. Where grape clusters were wet with the Bordeaux mixture *early and often* they were saved from rot. Where not thus sprayed they were entirely destroyed. The following table shows the yield of a number of treated and untreated vines; the berries in all cases were gathered from adjacent rows and carefully weighed:

Description.	Yield of grapes.	Description.	Yield of grapes.
	Pounds.		Pounds.
Section 3:		Section 5:	
13 vines treated with Bordeaux mixture.....	80	14 vines treated with eau celeste No. 2.....	14
13 vines untreated.....	2½	14 vines untreated.....	4
Section 4:		Section 6:	
13 vines treated with eau celeste No. 1.....	6½	25 vines treated with sulphatine.....	20
13 vines untreated.....	2	25 vines untreated.....	4

The following experiments made by Colonel Pearson are interesting, as they show conclusively that the rot can be prevented by the Bordeaux mixture:

In a vineyard untreated by rot preventives I applied several thousand grape bags, beginning before the grapes bloomed. On successive rows of Concord I put 200 bags every day (dating the bags), beginning before the vines were in blossom, and continuing until grape-rot appeared epidemically. On July 30 the bagged grapes were inspected, and in the bags applied until June 22, inclusive, it was found that they were generally free from rot, while those bagged on June 23 and subsequently were badly rotted.

This experiment indicates that the invasion of the disease occurred seriously after June 22, a. m., when the bags for that day were applied, and *before* June 23, a. m., when the bags for that day were put on.

On June 23, p. m., was a thunder-storm and slight spatter of rain. If this rain had come *before* the grapes were bagged on June 23, the invasion of the rot might be accounted for at that date through the supervention of the rain. But the grapes were bagged in the morning, during intense heat and drought, and the rain was not until afternoon.

Extended inspection of these bagged grapes made recently discovers the interesting fact that the infection of black-rot may enter the grape before it blossoms. The clusters bagged early are generally safe from rot, but there is occasionally seen in them one or two berries destroyed by the first invasion of the fungus. There is just enough evidence to prove that the infection probably occurred as stated.

After removing bags from grape clusters on August 1, I tried if these might be protected from rot during the rest of the season by an application of the Bordeaux mixture on August 4.

It was raining at the time the bags were taken off on August 1: a few rotted grapes appeared on these clusters on August 12.

I then took the bags from many clusters and sprayed these immediately with the Bordeaux mixture. At the same time I left some clusters (from which the bags were removed) unsprayed. The latter showed in a few days the spots indicative of infection by the rot germs: the former remain healthy and are now (September 24) ripe.

IV.—EXPERIMENTS AT NEOSHO, MO.

The experiments in Missouri were conducted at Neosho by Mr. Hermann Jaeger. The first applications of eau celeste, Bordeaux mixture, and sulphatine were made from May 1 to May 10. The second applications were made from June 4 to June 10. Black-rot first appeared on the foliage of both treated and untreated vines—but less on the former—on June 8. June 12 to 15 a third application with the same remedies as before was made, care being taken to thoroughly

spray all the fruit; June 23, a fourth application was made. On July 1 a thorough examination of all grapes was made and it was found that Martha, Concord, Telegraph, Goethe, and other Labrusca and European hybrids had from 30 to 40 per cent. of their fruit destroyed by black-rot on all untreated vines. The same varieties treated with eau celeste had from 20 to 30 per cent. of their fruit destroyed, while those treated with Bordeaux mixture had hardly 15 per cent. destroyed. Ten vines thoroughly sprayed with the Bordeaux mixture on the 23d of June had not lost over 8 per cent. of their fruit from rot. On August 1 all the vines were examined and the following table was prepared :

Variety.	Per cent. destroyed by black-rot.			Variety.	Per cent. destroyed by black-rot.		
	No treat-ment.	Eau celeste.	Bordeaux mixture.		No treat-ment.	Eau celeste.	Bordeaux mixture.
Perkins	1	1	.5	Noah	30		15
Ives	2	1.5	1	Missouri Riesling	1.5	.4	2
Martha	40	30	26	Hermann	40	30	25
Concord	50	35	25	Norton	.4	.3	1
Catawba	55	40	35	Neosho	5	4	2
Telegraph	65	55		Linceumii No. 9	75		
North Carolina	75	70	65	Racine	60	50	40
Delaware	30	18	3	Linceumii Nos. 13, 43	0	0	0
Herbmont	75		70	Est. x Rupestris 70	2	2	1
Goethe	70	60	60	Rupestris type	0	0	0
Elvira		6	.3	Average	31.7	18.8	16.8
Uhland	20	15					

From August 25 to August 30 all vines were again treated. On September 10 the vines were again examined, but as the earlier varieties had been gathered, a comparison could only be made between the late grapes, which were of the *Estivalis* species; these, however, on both treated and untreated vines, were quite as sound as when examined the month before.

Concerning the efficacy of the copper remedies for downy mildew (*Peronospora viticola*) Mr. Jaeger says:

There is no doubt that Elvira, Delaware, and all vines that are usually seriously damaged by mildew here were greatly benefited by the remedies, and their vigorous growth, matured to the tips, promises a better crop next season than ever before.

Mr. Jaeger concludes his report as follows:

With these remedies (especially the Bordeaux mixture) applied *early* and *often*, we can certainly reduce the ravages of black-rot, and it is quite possible that we may yet succeed in preventing it with as much certainty as mildew.

V.—EXPERIMENTS AT CHARLOTTESVILLE, VA.

Mr. H. L. Lyman conducted the experiments at Charlottesville, using nine different remedies, as follows:

1. Sulphatine:
 - Anhydrous sulphate of copper.....pounds.. 2
 - Flowers of sulphur.....do.... 20
 - Air-slaked lime.....do.... 2
2. Bordeaux mixture (a):
 - Sulphate of copper.....pounds.. 8
 - Lime.....do.... 10
 - Water.....gallons.. 20

Black-rot first appeared on the Labrusca and Vinifera hybrids June 11, and continued to increase until August 9. Downy mildew was first seen on May 27.

Experiments were also made by Mr. Lyman with the view of discovering a remedy for anthracnose. Mr. Lyman writes:

I determined to make an experiment for the prevention of anthracnose, because of the great amount of damage done by it in 1886 and 1887 to my Elvira and Delawares, and also because of its prevalence among other varieties grown in my neighborhood. The preparation used was a saturated solution of sulphate of iron which was applied in the latter part of February, and in the following manner:

Cheap, coarse sponges were wired to the ends of round sticks 15 inches in length; and buckets were used having a spatter strip nailed across the top. The sponge was immersed in the liquid, withdrawn, struck against the spatter strip to save waste, and the vine then swabbed thoroughly from the base to the extremity. Five hundred and fifty vines were treated and fifty left untreated. The entire absence of this fungus where the vines were treated led me to believe that the effects of the application were most satisfactory. The rows of Elvira untreated lost from 20 to 25 per cent. of their fruit, while the untreated Delawares did not bear any grapes worth mentioning, and made a very inferior growth of cane.

Mr. Lyman concludes his report as follows:

The difference in the quantity of fruit and quality of *must* between my treated and untreated Norton's Virginia was so marked at the wine cellar as to call forth the following communication:

CHARLOTTESVILLE, VA.

In receiving grapes from H. L. Lyman, delivered to and bought by the Menticello Wine Company in September and October, 1888, we found a very marked difference in the Norton grapes treated for mildew and rot by the application of copper mixtures from those not so treated. This difference was shown, not only in a much less degree of rot, but more in the *quality*, as indicated by the saccharometer. Those treated were rich in sugar, and consequently of an increased value of one-half a cent per pound or \$10 per ton.

OSCAR REIERSON, *Secretary*.

VI.—TREATMENT OF BLACK-ROT IN ARKANSAS WITH THE SIMPLE SOLUTION OF SULPHATE OF COPPER.

By MR. J. HERTLEIN, of Spilerville.

I used the simple solution of sulphate of copper (1 pound of copper to 20 gallons of water) because I could not get the ammonia which is used in the preparation of cauceleste. The first applications were made with a broom on the evenings of April 17 and 19, respectively. Four hundred vines of thirty-five varieties were treated, and one row in the middle of the vineyard was left untreated for comparison. The solution was too strong: it injured the leaves of some varieties badly, especially Norton's, Ives, Missouri Riesling, and Berckman's. Delaware did not suffer any, Concord very little. I made the second application May 2 and 3, and left Norton's and Ives untreated. Most of the vines were in bloom at the time. The third application was made between May 16 and 21, using the same solution as before. For the second and third applications I used 30 gallons of water to 1 pound of the copper, the part of this solution put on in the morning when the dew was on the leaves and after a rain burnt the foliage, while that put on in the evening did not hurt it in the least. The best time for applying the remedies I think is about sundown, or even by moonlight. Mildew appeared after a heavy rain on untreated Peter Wylie and Vergennes vines May 16; it also attacked some untreated Berckman's vines. May 17 I found spotted leaves on untreated Concord; on the 18th I gave the mildewed vines a sprinkling of the solution, which stopped further progress of the disease.

May 26 I found the first traces of black-rot on untreated Peter Wylie, also on Vergennes, and a few days later on Concord and other varieties. The 1st of June I commenced picking off the rotten berries (as I have done for the past three years), and kept on picking every three or four days until July 7; I picked in all about 50 pounds of rotten fruit. The difference between treated and untreated vines could be seen at a glance; while the treated ones were only slightly attacked, the untreated rotted badly. Not all the varieties yielded alike to the remedy, and while I could not see any difference between treated and untreated Berckman's and Vergennes, the difference between treated and untreated Concord was very striking. At the

harvest (August 6) the treated vines yielded over 10 pounds to the vine, and the untreated 3½ pounds. Delaware and Norton's were nearly exempt from rot; Ives, Montefiore, Ulster, Empire State, Perkins, and Champion rotted very little.

My vineyard is on a slope with western exposure; one half is trained to wire after the Kniffen system, the other half to stakes. In the spring before the buds started I washed every alternate row of those on wires with a 50 per cent. copperas solution, and on these I could hardly find a rotten berry in the fall. I have full confidence in the remedies, and will experiment again next season. The main thing is to use the remedies early, before and immediately after flowering. I believe that 1 pint used at such a time will do more good than a gallon used later. Picking and destroying the rotten berries should be continued with the foregoing treatment. All the vineyards of my neighbors, where no remedies were applied, were injured by rot from 25 to 75 per cent., while I hardly lost 1 per cent. of my crop.

VII.—EXPERIMENTS AT MIDDLE BASS, OHIO.

Mr. George M. High, of this place, sent in a very full report of his experiments, and the results obtained in the treatment of brown-rot (*Peronospora viticola*). He used eau celeste, making the applications with a Nixon barrel force pump and Nixon spraying nozzle on June 7, June 18, July 6, July 18, and August 7. Two thousand vines, mostly of the Catawba variety, were treated, while a like number of the same variety were left untreated for comparison.

The loss of fruit on the treated vines was about 1 per cent., while on the untreated vineyard fully one-third of the fruit was destroyed.

VII.—TREATMENT OF THE GRAPE-VINE POWDERY MILDEW (*Uncinula ampelopsidis*) WITH SULPHURET OF POTASSIUM.

Mr. E. M. Hudson, of Mobile County, Ala., used this solution in the treatment of the foregoing disease, and his report contains so many interesting points that it is here submitted in full.

I was making an effort to find some convenient form of sulphur to apply to my European vines (*Vitis vinifera*), when I was attracted by an observation of M. le Vte. Amaury de Montlauer, in Bulletin No. 2 of the Section of Vegetable Pathology, pages 68 and 70, to the effect that he had successfully applied a 1 per cent. solution of liver of sulphur for mildew (*Peronospora viticola*); and he concluded by saying that vineyards treated in the spring had neither *Oidium* nor *Erineum*. I at once decided to experiment with it on Hamburg, Black Hamburg, Muscat, and other European vines growing in the open air, on which, for several seasons, the grapes have been severely injured, and in 1886 entirely destroyed by the powdery mildew (*Uncinula ampelopsidis*). Accordingly I commenced with a 1 per cent. solution, which scorched the young leaves severely wherever it touched them. Next I made a solution of one-tenth the above strength; this was also too strong but the beneficial effects were so apparent that I made a third application, containing one one-hundredth of 1 per cent. of the potassium. This, while promising far more than the two former mixtures, still admonished me that the solution was even then too powerful. Notwithstanding these disappointments, I succeeded in saving a portion of the crop in fair condition.

This year I commenced, when the young shoots were perhaps 6 to 8 inches long, with a solution of half an ounce (avoirdupois) to one gallon of water. It was applied again when the grapes were beginning to color. The solution happened to be quite powerful enough and produced no injurious effects whatever on the tender leaves and shoots. This treatment was applied to two hundred vines (all marked) with absolute and unexceptional success, giving me a full crop of superb clusters of magnificent berries in every instance. About thirty-four vines, interspersed among those treated as above, and left entirely untreated, had their entire crop destroyed by the mildew.

After the crops were gathered the older leaves on the treated vines were attacked by the *Uncinula*, and before they could be treated a long rainy season of six weeks set in so that the remedies were never applied. At the end, however, the foliage of the treated vines, beyond being browned slightly, appeared to have received no further injury, and the late wood growth was satisfactory.

I used the Vermorel machine in applying the solution and it gave perfect satis-

faction. I had the solution freshly prepared and applied it in the early morning, before 8 o'clock, as recommended by M. de Montlaur.

When you take into consideration the cheapness of liver of sulphur, the ease of its preparation and application, the complete success of the treatment, and the fact that the ripe clusters are not blemished by it as they are by the flowers of sulphur, it seems to me that it must commend itself to all growers of European vines, especially those in California, where the *Uncinula* is the chief fungous disease against which grape-growers have to contend.

In preparing the solution, half an ounce of the liver of sulphur was dissolved in 1 pint of hot water; as soon as dissolved, the cold water (1 gallon less 1 pint) was poured with the hot solution, and the whole immediately strained through a thick osnaburg cloth into a tin can and closely stopped. It was then ready for use. It takes but a few moments to prepare it. From the tin can (10-gallon cans were used) the mixture was poured, as needed, into the reservoir of the Vermorel machine and sprayed thoroughly over the vines, clusters, and leaves above and below, the smaller nozzle being used for the work.

I used at each application on two hundred and fifty vines 4 gallons of water with 2 ounces of liver of sulphur. This was perhaps more than was necessary, but I was determined to have the work done efficiently and thoroughly in order to test the value of the application.

IX.—CONCLUSIONS.

The results furnished by the foregoing reports show conclusively that by the proper application of the copper remedies, especially the Bordeaux mixture, we may subdue or even entirely prevent black-rot. Downy mildew can easily be prevented by any of the remedies mentioned in the foregoing circular, as the experiments last year fully proved. It is true that quite a number of those who made trials this year report that no benefit resulted from the applications, but when we come to carefully inquire into such cases we find that where failures are reported the experiments were either carelessly made or were begun too late in the season to be of value. It seems to us that one of the principal reasons for the non-success heretofore attending the use of these preparations lies in the fact that very few grape-growers have the vaguest idea of what the fungi of black-rot and downy mildew are like. They do not know that these minute enemies are plants like the vine on which they feed; that they grow and produce bodies analogous to seed, and that these minute seed or spores germinate and take root, so to speak, whenever they come in contact with the fruit or leaves, providing there is sufficient moisture present. If these facts, and many others connected with the life history of the fungi under consideration, were known, the importance of beginning the treatments early and making the applications thorough would be readily understood.

Under the present condition of things it is somewhat difficult to outline, in a definite manner, a practical course of treatment for black-rot. As a first step, however, it would be well to carefully collect in the fall as many of the old leaves and berries as possible, and burn or bury them. Then in the spring after the vineyard has been pruned and put in order by the plow, but before vegetation starts, the vines should be thoroughly sprayed with Bordeaux mixture containing 16 pounds of sulphate of copper and 30 pounds of lime to 22 gallons of water. The object of this spraying is to destroy all the spores of the fungus that may have lodged in the bark. About ten days before the flowers open the foliage and vines should receive a second spraying, this time using a mixture containing 6 pounds of sulphate of copper and 4 pounds of lime to 22 gallons of water. A third application, using the latter mixture, should be made when the flowers are opening, taking care to thoroughly wet all the green parts but not to drench them. Repeat the spraying every two

weeks, until the fruit begins to color, using the same preparation as before.

In regions where both mildew and rot prevail, the treatment as outlined for the latter will effectually prevent the former so that it will not be necessary to make any additional applications. Where the mildew is the only enemy to be considered the eau celeste (formula 1 or 2) should be used for the reason that it is cheaper, more readily prepared and applied, and fully as efficacious in this case as is the Bordeaux mixture.

On the 1st of December, 1888, we visited Colonel Pearson's vineyard and found that he had already begun treating his vines with the view of preventing the recurrence of black-rot in 1889. He had thoroughly cleaned his vineyard and had removed all the old bark and dried berries from the vines. The vines had been drenched with the Bordeaux mixture, and slaked lime had also been scattered between the rows, completely covering the ground in many places. Colonel Pearson informed us that he would plow the vineyard in the spring before vegetation started and again give it a liming, after which he would apply the Bordeaux mixture, repeating the sprayings every three weeks throughout the summer until the fruit began to color.

B.—NECESSITY FOR MORE EXTENDED FIELD WORK.

Among the subjects dealt with in the following pages the rot of the potato, tomato, and cherry, and the leaf-blight, and cracking of the pear cause the heaviest losses to farmers and fruit-growers. Each one is probably the cause of thousands of dollars' loss every year, and they are only representative diseases. The agricultural world has long suffered from these diseases in a profound ignorance of their causes.

Against these insidious foes, which are visible only in their effects, the farmer has heretofore had no weapons of warfare. If his potato vines died prematurely, and the potatoes themselves rotted in the hills or in the cellar, he simply said it was a bad year, resigned himself to his fate, and probably used what few potatoes were left for planting his next year's crop. Since this Section was established a continual effort has been made, by means of correspondence, special bulletins, and annual reports, to bring before the agriculturists of the country the fact that these diseases have definite causes outside of climatic influence, to teach them the nature of these causes, and that the diseases can be prevented. The liberality of the Government in circulating large editions of these reports has done much to bring this knowledge within reach of all, and there is no good reason to-day why agriculturists should longer suffer in unresisting ignorance of the causes or remedies for fungous diseases. Much work in this line remains to be done. The entire history of the fungi causing these diseases is known only in a comparatively few cases; and how important it is that the entire history of all parasitic fungi should be known may be gained by a study of those already described. But in addition to this there is another field of labor which is absolutely necessary if this knowledge is to be made of practical benefit. Under the "treatment" of nearly every disease we are obliged to say, "No experiments have yet been attempted, and the suggestions made are drawn from a general knowledge of the life history of the fungus and the results in the use of fungicides in vine diseases." In other

words, we leave our readers to experiment for themselves, doing all in our power by way of suggestion.

This is not encouraging to farmers; considerable expense is entailed in order to thoroughly test any of these remedies, and few care to add to the possible loss of their crops the additional expense of chemicals and machines for application, to say nothing of the labor involved at a time when other work is especially pressing. If, on the contrary, we were able to lay down a course of treatment and say *This has been thoroughly tested by competent and practical men*, no farmer would hesitate to use the means suggested.

The need of this has been keenly felt by those in charge of the work, but the funds available have not been sufficient to establish any such series of experiments as was desired. It was thought wisest to concentrate what money and force it could command in this direction upon one point, and consequently all available resources were used for two years in experiments with fungicides for black-rot and other diseases of the grape. The result has justified the means and we are now able to say to the grape-growers of the country that this most dangerous foe to their industry may be conquered by a simple and comparatively inexpensive method. One of the results of this work is the invention of the Eureka sprayer, and the number of orders already received for it attest the fact that fruit-growers are anxious to use remedies that have once been tested. It remains for us to make similar experiments in other diseases, but if two years must be devoted to each one our progress will be painfully slow. The demand for more field work is imperative, the resources of the country can never be fully developed while the agricultural community is at the mercy of every infectious disease that now visits its crops. The losses from this source are incalculable, and it devolves upon this Section to take the initiative steps toward avoiding them. The work is possible and extremely practical, and what is necessary in order to accomplish the desired results is to have the funds at our command that will enable us to employ competent men to go into the field and not only investigate the causes but experiment with remedies for the many diseases that are now devastating nearly every cultivated plant.

C.—MISCELLANEOUS SUBJECTS.

The following subjects are discussed in the accompanying pages of this report:

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| 1. Downy mildew of the potato. | 9. Apple rusts. |
| 2. Notes on black-rot of the tomato. | 10. Septosporium on grape leaves. |
| 3. A tomato disease. | 11. Leaf-spot disease of the maple. |
| 4. Brown-rot of the cherry. | 12. A disease of the sycamore. |
| 5. Powdery mildew of the cherry. | 13. The leaf-rust of cottonwoods. |
| 6. Leaf-blight and cracking of the pear. | 14. Report on peach yellows. |
| 7. Leaf-spot of the rose. | 15. Additional notes on celery leaf-blight. |
| 8. Plum-pockets. | |

The paper on "Downy Mildew of the Potato" was prepared by Prof. F. L. Scribner, while that on "Apple Rusts" is by Dr. B. D. Halstead, who has given special attention to this group of fungi. Of the remaining chapters my assistant, Miss E. A. Southworth, prepared Nos. 6, 7, 10, and 12, and also furnished valuable notes on several others. Chapters 5 and 13 are from the pen of my assistant, Mr. M. B. Waite. The illustrations accompanying these were drawn

under my supervision by Miss Roberta Cowing, Miss E. A. Southworth, and Mr. M. B. Waite.

1.—DOWNY MILDEW OF THE POTATO.*

Phytophthora infestans, DBY.

(Plates I, II, and Map.)

I.—GENERAL REMARKS.

The disease of the potato caused by the parasitic fungus *Phytophthora infestans*, generally known as Potato-rot, probably originated in South America, whence it was brought to this country about the year 1840. Since that time it has been the cause of very serious losses to farmers, and in years favorable to the disease has swept away nearly the entire crop.

The cooler and more moist sections of the country are where the *Phytophthora* attains its greatest vigor and activity, and it is only in the dry regions of the great western plateaux that the potato-grower can hope to wholly escape its ravages.

No variety has yet been discovered that has remained free from the disease under all circumstances, although in some localities some varieties are more resistant than others. Possibly also there are some varieties more susceptible than others, and these should be known in order that their culture may be avoided.

II.—BOTANICAL CHARACTERS.

The fungus attacks the stems and leaves as well as the tubers.

On the leaves (Plate I, Fig. 1) pale-yellowish spots first indicate the presence of the disease; these very soon turn brown, and if the weather be warm and damp, rapidly blacken, indicating the total destruction of the tissues. The yellowing of the tissues progresses slowly, but as soon as the fungus has pushed out its fruiting threads, which appear as a white downy coating on the under surface, the discolorations proceed rapidly.

The stems may be attacked directly or the disease may reach them through the leaves; in either case they become blackened and soon die.

On the tubers (Fig. 2) the parasite attains a considerable growth within the tissues before there is any external manifestation of its presence. After a time depressed spots appear and the skin covering these dies and becomes discolored. Underlying these spots the tissues will be found to be dark-colored for a greater or less depth. This browning of the tissues begins before there is any external sign of disease. The flesh occupying the center of the tuber remains for sometime healthy and normal, but in the end it also decays either with dry or wet rot. If infected tubers are stored the rot will progress in the cellar and healthy tubers may be infected by those already diseased. The losses arising from the rotting of the tubers after they are gathered sometimes amount to as much as may have occurred in the field.

* This article is an abstract from a paper by Prof. F. L. Scribner which will be published as a special bulletin.

The mycelium passes between the cells, never into them (Plate II, Figs. 1, 4) except in rare cases. After it has grown a few days in the tissues of the leaf, it sends out branches destined to bear the conidia or reproductive bodies of the fungus (Fig. 2). The method of formation of the conidia is illustrated in Fig. 3. They are formed at the apex of the conidiophore or its branches, and their apparently lateral position is due to the fact that they are turned to one side by a continuation of the growth of the branch. As soon as the conidia are ripe they will germinate if placed in suitable conditions of warmth and moisture. The changes which they pass through in germination are illustrated by Fig. 5. The conidium breaks up (*a-d*) into a number of motile portions called the zoospores (*e, f*.); these have cilia at first, but finally lose them (*g*), surround themselves with a membrane and germinate (*h, i, k, l*); the germ tube enters the plant and reproduces the disease.

There is no longer any doubt that the tubers may be and usually are infected by the rain washing the conidia down into the soil.

III.—CONDITIONS FAVORING THE DISEASE.

In order to intelligently treat the potato-rot it is necessary to understand the conditions which favor its development. These are (1) humidity—the years of great outbreaks have always been years of excessive humidity; (2) a temperature ranging from 65° to 75° F.—a few degrees above 74° will check the development entirely, and down to 45° the fungus will continue to grow; (3) moisture in the soil—hence a clayey soil or one that will retain moisture is more favorable to rot. It is also generally conceded that stable or barn-yard manure, especially if used fresh, favors the rotting of the tubers.

The conditions which favor the rot after the potatoes are harvested are the same as those which favored it before—moisture and a moderately high temperature.

IV.—TREATMENT.

Treatment for potato-rot must be preventive, and prevention in this case consists, first, in not planting diseased tubers, and second in making the conditions unfavorable for the germination of the spores and development of the mycelium, and finally in protecting the tops by fungicides that will prevent the spores from germinating even under the most favorable climatic conditions.

Potatoes used for seed should be perfectly sound; a single tuber containing the mycelium of the fungus may result in a point of infection that will ruin the entire crop. If there has been any disease in the field where the seed potatoes were grown it is not safe to depend upon observation in judging the character of seed selected, for the *Phytophthora* may be present without developing any visible characters. The better plan would be to always disinfect the tubers designed for seed. Whether this can be done without destroying the vitality of the sets must be determined by further experiments. According to Mr. Jensen, however, it is possible to disinfect potatoes to be used for seed by keeping them in an oven for a few hours at a temperature of from 104° to 110° Fahr.

When possible the planter should always select a light and thoroughly drained soil for his potato crop. It is of course impossible to control the weather conditions that favor the disease, and conse-

quently if these are present the vines must be protected by the application of fungicides. The disease is similar to the downy mildew of the grape, and the preparations used for that will be effective for the potato-rot. Preference is given to the Bordeaux mixture, but eau celeste, sulphatine, and blight powder can also be recommended. The applications should be made when there is no wind, and the plants are wet with dew, and should begin before the blight makes its appearance, say during the latter part of July, and repeated about the middle of August.

If the spores of the fungus reach the tubers by being washed into the soil by rains, potatoes but lightly covered with earth are more likely to be infected than when deeply planted; such is generally reported to be the case, consequently the potatoes should have a second or protective molding at the first appearance of the disease upon the leaves, made in such a manner that the uppermost tubers shall have at least 5 inches of earth over them, the tops being bent at the same time so that they hang over the furrows in a half-erect position.

It should be remembered at the time of digging the crop that the tubers may become infected as they are taken from the ground, by spores from the decaying tops. If the digging be delayed for a week or two after the tops have become thoroughly dead, and performed when the weather is sunny and dry, there is little possibility of infection at this period.

Potatoes should be entirely free from surface moisture when stored, and never should be placed where it is damp or where moisture can collect about them. Dusting the tubers with air-slaked lime (1 bushel of lime to 25 bushels of potatoes) before storing is strongly recommended; it will do much towards preventing the rot. If during the winter the potatoes are found to be rotting they should at once be sorted over and all spotted or unsound ones treated with lime and stored where the temperature is low and the atmosphere dry.

2.—NOTES ON BLACK-ROT OF THE TOMATO.

(Plates III, IV.)

I.—GENERAL OBSERVATIONS.

Horticulturists and farmers have suffered considerably of late years from a disease of the tomato which is known everywhere as "rot." The term as generally used includes a number of diseases which are quite distinct from each other. It is not, however, the purpose of this paper to enter into a discussion of the various kinds of rot; we shall rather attempt to bring together some of the facts concerning one very important form which has come more particularly under our observation during the past year, and in order to distinguish it from similar diseases it will be here designated as "black-rot."

Specimens of this have been received from nearly all parts of the United States where the tomato is grown, and farmers complain bitterly of its ravages.

Although several mycologists have devoted considerable time and study to the malady, the results so far obtained as to the cause of it are far from conclusive or satisfactory. Doubtless this is owing to the fact that the rot is not always the result of a single agent, but is more often due to several combined causes.

II.—EXTERNAL CHARACTERS.

The disease as a rule makes its appearance at the apex or flower end of the fruit when the latter is from one-half to two-thirds grown. At first a small blackish spot is seen either around the remains of the style or on one side of it; this rapidly increases in size, but retains a more or less circular outline (Plate III, Fig. 1). As the disease progresses the tissues collapse quite regularly on all sides, and the berry becomes much flattened (Fig. 2). There is usually a slightly raised, narrow border surrounding the diseased parts, while just outside this the cuticle retains its normal healthy color, but appears slightly wrinkled, owing to the collapsed condition of the tissues beneath. Sections through a rotten tomato at this stage show that the black discolorations extend deeply into the tissues, the depth depending somewhat upon the size of the spot. As the malady progresses the diseased parts become hard and leathery, the surface assumes a greenish-black, velvety appearance, and finally the entire fruit becomes dried and shriveled.

III.—LOSSES, CONDITIONS KNOWN OR SUPPOSED TO FAVOR THE DISEASE. ETC.

In parts of Indiana, Michigan, Wisconsin, and Mississippi the disease is very destructive, in many cases causing almost a total loss of the crop. The following extracts from correspondence will give some idea of its ravages.

A correspondent writes from Montgomery County, Ind., as follows:

The black-rot of the tomato has prevailed to an alarming extent in this locality for the last three or four years, affecting, however, only the first-formed fruit, but eventually destroying fully one-third of the crop.

Professor Taft, of the Agricultural College of Michigan, says:

The only severe cases of rot which troubled us this summer were on a dry sandy knoll, and occurred during the drought of August. The vines were not trellised, and the fruits which rested on the ground were affected on the under side. We had only a few varieties on this place, and the "Mikado" and "Acme," with other pink kinds, seemed to be most injured. Upon our experimental plot, which contained one hundred and fifty varieties, only an occasional fruit was diseased.

Professor Tracy says that at Crystal Springs, Miss., he found the disease very severe on April 24, 1888, fully one-fourth to one-half the fruits being affected in a number of fields examined. On May 1 nearly one-half of the fruit in some fields was affected, and on June 1 the disease had nearly disappeared. In July he was unable to find specimens for study.

In Wisconsin (writes Professor Tracy) it appears in July or August and continues until frost. In one garden there it has been noticed as affecting the crop very seriously for three years, but this year, with no noticeable peculiarity of the season, it was not to be found on plants grown on the same ground from seeds of plants affected last year.

He concludes by saying that he tried sulphatine, David's powder, etc., this year, but as the disease disappeared from untreated plants soon after, the results were negative.

As stated above the fruit is most subject to attack when two-thirds grown, and, from the reports of correspondents, it appears that the disease is especially virulent during the latter part of July and the whole of August. It is also generally believed that it is most severe in seasons when wet weather prevails at the time the fruit begins forming.

In response to a number of inquiries, sent out by the Section to determine, if possible, what effect the character of the soil, pruning, trellising, manuring, etc., had upon the disease, a number of replies were received, but the opinions expressed in these are so contradictory that no practical conclusions can be drawn from them. According to Professor Maynard of the Massachusetts Agricultural College, the rot this year was more severe upon soil where there was only a limited supply of manure applied. Professor Taft expresses practically the same opinion as that of Professor Maynard.

Professor Bailey* says that an abundant use of stable manure appears to augment the disease; and this seems to be the general belief of most of our correspondents.

From the observations of Professor Goff of the New York Agricultural Experiment Station, the rot appears to flourish most on the more vigorous plants. He says that a vigorous plant of "Cook's Favorite" tomato, grown from mature seed, had 18 per cent. of its fruit affected with black-rot; while a feeble one, grown from immature seed, had but 5 per cent. of its fruit destroyed.

Some varieties appear to be more subject to the rot than others. It appears from all the evidence at hand that the "Acme" and "Mikado" are especially subject to the disease, while the "Perfection," "Paragon," and "Trophy" are not so liable to its attacks.†

IV.—CONCLUSIONS AS TO THE CAUSE OF BLACK-ROT.

In all the specimens which have come under our observation during the past year, we have invariably found two species of fungi; finding these always associated with the rot, the questions naturally arise as to what connection they have with the disease, and whether they are really the cause of it or are to be considered as a simple incident of the malady. In order to discover if possible the relationship existing between the two fungi and the rot, a study of the former was begun, and the results of these observations are as follows:

A section through one of the velvety, greenish spots shows that the color and peculiar appearance are due to the presence of a vast number of short, dark, olive-brown threads (Plate III, Figs. 3, 7), upon the free ends of which are borne obclavate, many celled bodies (Fig. 5): these readily separate from the supporting stalks, and are found thickly scattered over the surface of the diseased parts. Associated with this fungus is another which consists of dense tufts of nearly colorless, club shaped stalks, occasionally bearing crescent-shaped, slender bodies, much smaller than those first described (Plate IV, Figs. 1, 2, 3). The dark-colored fungus is *Macrosporium tomato*, Cook,‡ while the colorless species is a *Fusarium*, which agrees with specimens and descriptions of *F. solani*, Mart.,§ a species commonly found

* "The worst cases of rot this year (1887) occurred upon plants grown on a freshly turned sod which had been previously dressed with manure."

† According to Professor Bailey, the angular, pear-shaped, and cherry varieties, and those immediately derived from them, have been almost exempt from attack.

‡ *Macrosporium tomato*, Cook. (Grevillia XXII, p. 32. "Spots orbicular: hyphæ short, large, flexose, septate; conidia clavate, slightly attenuated above, short stalked below, consisting of brownish spheroidal cells. On ripe tomatoes, S. Carolina (Ravenel).") Our specimens do not agree with the foregoing description in all cases, but a comparison of the material at hand with authentic specimens of *M. tomato* shows that the two forms are identical.

§ The so-called *Fusarium* which occurs abundantly on rotting potatoes has been pretty thoroughly studied by the German mycologists Reinke and Berthold. Their investigations resulted in the discovery of the mature or asporous form on old and

- on rotting potatoes. The *Macrosporium* is usually the more abundant of the two, and while it is, as a rule, found upon spots of all sizes, the *Fusarium* rarely appears until decay is pretty well advanced.

V.—MICROSCOPIC CHARACTERS OF THE MACROSPORIUM.

The *Macrosporium* consists of a mycelium or vegetative system, spores or reproductive bodies, and spore-bearing hyphæ.

Mycelium.—The vegetative part of the fungus is made up of rather large, septate, thick walled, more or less contorted tubes which are at first nearly colorless, but eventually become tinted with brown; these are found in all of the decaying parts and can be readily traced into the sound tissues (Plate III Fig. 7a). They are especially abundant near the surface, forming here pretty evenly distributed, more or less dark colored mats.

Spores.—The spores are borne upon the ends of short or long, septate, olive-brown, rather thickish hyphæ (Plate III, Figs. 3, 4, 7), which spring from the dark-colored mycelium. They are made up of from three to fifteen spherical cells, and vary greatly in size and shape, being when full grown broadly obclavate, and from 20 to 25 μ in diameter by 100 to 140 μ in length (Fig. 5). Their color at first is olive-brown, later they become darker, frequently almost black. They germinate readily in moist air or water by sending out one or more slender tubes from each cell (Fig. 6). At first the germ tubes are colorless and without septa; later they become tinted with brown and divided by frequent cross-walls.*

VI.—MICROSCOPIC CHARACTERS OF THE FUSARIUM.

This fungus, so far as we have been able to trace its development upon the tomato, consists of a vegetative part, or mycelium, and spores or reproductive bodies of two kinds, namely, macroconidia and microconidia.†

Mycelium.—The mycelium or plant body of the fungus consists of delicate, colorless, septate threads, which penetrate the tissues of the fruit in all directions, appropriating the juices for its own sustenance. It is much more abundant than the mycelium of the *Macrosporium*, and differs from the latter in being more slender, lighter colored, thinner walled, and not usually contorted; another difference is that while the mycelium of the latter is confined for the most part to the surface, that of the *Fusarium* is frequently found in the center of the fruit, and shows a much greater tendency to penetrate

badly-decayed potatoes. According to these authors this form consists of pear-shaped perithecia, within which the asci with their contained sporidia are borne. The swollen part of the perithecium is of a bright-purple color while the neck is bright orange. This form has been referred by Reinke and Berthold to the genus *Hypomyces*, and by careful experiments they have proved beyond question that it is the mature stage of *Fusarium solani*, Mart. This being the case, the generic name *Fusarium* has been dropped, and the name *Hypomyces* is now made to include both forms. So far as the life history of the fungus occurring upon tomatoes has been traced it agrees essentially with the *Fusarium* form found upon the potato. Moreover, the spores of the tomato fungus when sown upon the potato grow readily. We are not aware, however, that the ascosporeous form has ever been found in this country either upon the potato or tomato, and until this is accomplished the relationship existing between these forms can not be definitely proved.

*Both the hyphæ and spores are exceedingly variable: at times the former are long and nodulose and bear spores which can not be distinguished from those of the genus *Cladosporium*.

† *Macroconidia*, large conidia compared with others (*Microconidia*) produced by the same species.

the sound tissues. Thin sections, taken near the edge of a rotten spot, often show the ends of the mycelium penetrating the tissues where the contiguous cells are apparently healthy (Plate IV, Fig. 8).

Macroconidia.—These are the most important reproductive bodies, economically considered, as they are produced in prodigious numbers and doubtless serve for the rapid propagation of the fungus. They develop in several ways. The mycelium may rupture the epidermis in places, sending out tufts of club-shaped conidiophores, which form spores by constriction. The immature conidia appear to be merely the enlarged ends of mycelium threads (Figs. 1, 2). In another form the tufts are longer and denser, the base and center appearing like a colorless stroma, the conidiophores are branched and septate (Fig. 3), and each ultimate branch bears a macroconidium. On old and badly diseased tomatoes it is common for the mycelium to run over the surface, sending out numerous upright branches, each of which bears a spore at the end (Fig. 2). When full grown they are colorless, crescent-shaped, nearly cylindrical, and vary in size from 5 to 7 μ in diameter by 10 to 50 μ in length (Fig. 4). They are usually divided by from two to six transverse partitions or septa, and are filled with a fine granular fluid. Each division is provided with one or more vacuoles, which increase in size when the conidium is exposed to moisture. When sown in water they will, in a few hours, send out germ tubes (Fig. 5*a*), and these, by continual branching (Fig. 5*b*), soon develop into a mycelium. Before germination takes place the spores often become constricted at the partitions.

Microconidia.—The microconidia (Fig. 6) are usually found in great abundance in old and badly decayed tomatoes. As a rule they are borne upon short branches of the mycelium, and are spherical and smooth when young (Fig. 6*a*), but later become roughened with small wart like projections (Fig. 6*b*). At first their color is a light yellow; later this becomes brown. They vary in size from 8 to 16 μ in diameter, their average size being about 12 μ . They are filled with a granular fluid, and are provided with several large oil drops, which become more pronounced as the conidia approach maturity, but are not so well made out in the full green warty forms. These microconidia do not germinate readily under artificial conditions, often remaining for a month in water without undergoing noticeable change. In germinating (Fig. 7) they send out one or more slender tubes, which do not materially differ from those of the macroconidia.

Frequently macroconidia are developed directly upon these germ-tubes, and *vice versa* microconidia are occasionally developed upon germ-tubes from the macroconidia (Fig. 5*c*).

VII.—LIFE HISTORY.

As yet it is not definitely known how these fungi pass the winter. At this writing (December 1) both the *Macrosporium* and *Fusarium* spores can be found upon the dried and shriveled fruit which long ago fell from the vines. An abundance of the spores of the former fungus also occurs upon the old leaves and stems.

Upon a number of specimens of half rotten tomatoes collected in the Department grounds the latter part of September, a fungus was found which seems to be connected with the *Macrosporium*. As seen under the microscope, this form consists of rather large round or ovoid, dark colored bodies, which, as they increase in size, break through the tissues and appear on the surface.

In sections it is seen that they are filled with small round or oval

spores which escape through an opening in the top. Around this opening, and upon the outside wall, numerous tufts of hyphæ and spores of a *Macrosporium*, which do not differ from *M. tomato*, are borne. Considered independently the ovoid bodies or conceptacles, as they may be called, would be referred to the genus *Phyllosticta*, but there seems little reason to doubt that in this case they are really a part of the *Macrosporium*.

It is very probable that this fungus passes through several stages before finally reaching maturity, and that one if not more of its forms will be found during the winter in the old tomatoes destroyed the previous summer by the *Macrosporium*.

In regard to the *Fusarium* we have seen that at least two kinds of spores are produced. From the fact that the microconidia germinate with difficulty it is very probable that they are designed to preserve the life of the fungus during a greater part of the winter or under conditions which would prove fatal to the macroconidia.

During the month of September, 1888, when there was an abundance of fresh material at hand, a series of experiments was made with the view of discovering, if possible, whether the rot could be induced by sowing the spores of the *Macrosporium* and *Fusarium* on healthy tomatoes. In the first place, germinating conidia of the *Fusarium* were repeatedly sown on the uninjured surface of both green and ripe tomatoes, but in no instance was there any appreciable effect produced. Conidia were also inserted under the skin of green, half ripe, and ripe fruit, and while no change took place in the case of the green and half ripe specimens, the ripe fruit rotted in a few hours. A microscopic examination of the tissues of the latter showed the mycelium of the *Fusarium* running over, under, and through the cells in all directions and producing its characteristic crescent shaped spores in great numbers.

It has probably often been observed that tomatoes crack when exposed to excessive moisture; these cracks or fissures occur either at the point of attachment or at the style end of the fruit, but more often at the latter. They are often so small as to be nearly invisible to the naked eye, while at other times they are quite large and prominent. By way of experiment spores of the *Fusarium* were sown upon both green and ripe fruit, showing these fissures, and as a result the ripe specimens rotted completely in a few days but the green fruit was not affected.

Similar experiments to those described above were also made with the *Macrosporium* spores. In this case, however, infection of both green and ripe fruit was readily effected by inserting the spores under the skin or sowing them in the fissures to which we have already referred. When sown on the uninjured fruit no effect whatever was produced.

Another series of experiments was undertaken with the view of discovering, if possible, whether the *Fusarium* spores would grow when sown on green fruit affected with the *Macrosporium*. It was shown by these trials that the spores of the *Fusarium*, when sown on fruit already partly destroyed by the *Macrosporium*, grew readily and greatly accelerated the disorganization of the tissues.

Summing up the results obtained from the foregoing experiments it appears (1) that neither the *Fusarium* nor *Macrosporium* has the power of penetrating the sound cuticle or skin of the tomato; (2) that the *Macrosporium* spores, when brought in contact with the exposed tissue of either green or ripe fruit, produce the rot in a very short

time; (3) that the *Fusarium* will grow only in fully ripe tissues or tissues which have been partly disorganized through other agents.

VIII.—TREATMENT.

While our present knowledge of the disease is not sufficient to warrant us in indicating any definite line of treatment, it is probable that the malady may be prevented in a measure by observing the following precautions. Beginning in the fall it would be well to burn all the old vines, as we have already seen that the spores of one of the fungi at least occur abundantly on the leaves and branches.

All of the old and partly decayed fruit should also be burned or buried, thus securing the destruction of the fungus in whatever form it may live over winter. It would also be well to avoid the excessive use of fresh stable manure, as our observations lead us to believe that the fruit on plants thus fertilized is much more likely to crack, thereby opening a way for the fungus.

It is very probable that the fruit, as a rule, is first infected by the spores of the *Macrosporium*, which send their slender germ tubes through the minute fissures usually found at the apex or blossom end of the berry. After the *Macrosporium* has opened the way the *Fusarium* comes in and assists in the disorganization of the tissues. When practicable, therefore, it would be well to destroy the diseased fruits as soon as they appear, thereby destroying many spores which otherwise might possibly infect adjacent fruit.

So far as we are aware there have been no experiments undertaken to determine the value of fungicides in combating this disease, but by way of trial a solution made by dissolving one-half an ounce of sulphuret of potassium to the gallon of water might be used. This preparation should be applied by means of a spraying apparatus, taking care to thoroughly wet all parts of the fruit. The first application should be made when the fruit is about half grown, repeating the operation at intervals of ten days until the fruit begins to color.

The following report embodies the results of observations made on this disease at New Ross, Ind., by Dr. Homer S. Bowers, an agent of the Section:

IX.—REPORT OF DR. H. S. BOWERS.

The tomato in this section has been remarkably exempt from disease until within the last few years. Plants which escaped the dangers from late spring or early summer frosts, occasional ravages of the cut-worm and later attacks of the tomato-worm, were considered out of danger. But this condition of things is now changed, for within the last few years another enemy, which seriously threatens the profitable cultivation of this valuable fruit, has made its appearance in the form of a disease commonly known as tomato-rot.

This disease usually appears at the junction of the style with the ovary, and is first seen as a brownish black, scale like spot, dry and somewhat leathery in appearance, and sunken to some extent below the surface. In a few days it spreads over one-fourth, or perhaps one-half, the surface of the fruit, sometimes extending uniformly around the style scar, but at other times developing almost wholly on one side, leveling and depressing the surface as it extends. The berry at the same time becomes wilted and presents a blistered or scorched appearance, but at all stages there is a distinct contrast in color between the sound and unsound tissues. The diseased portions also become slightly wrinkled, and although they were before smooth and glabrous, they soon become glaucous from the growth of a powdery fungus, which is always found in connection with the malady. This mold does not occupy the whole of the diseased portions, but mottles the surface to a greater or less extent, presenting various blotches and markings, which vary in color from brown to a dirty brownish black.

It attacks the fruit in all periods of development, but preferably when from one-third to one-half grown, and when it has once made its appearance it progresses rapidly, especially in those fruits attacked early in the season; in a few days the vitality of the berry is destroyed, its growth ceases, and at the same time its color changes to that of the ripening fruit.

However long or short a time the disease may continue during any one growing season, it in nearly every case begins on the first fruiting stems of the plant, destroying all the fruit that forms on the first one or two clusters, afterwards attacking only a single berry here and there.

Little difference has been noted in the susceptibility of the different varieties, whether red or purple, smooth or corrugated, and though some slight exemption from the rot is claimed for the yellow kinds, further proof is needed to clearly establish it.

The annual loss in this vicinity for the last five years has been about 33 per cent. of the product of all plants attacked, or 25 per cent. of the whole crop. So far as we have been able to discover the disease seems to be pretty generally disseminated through this part of Indiana, although there are some localities of greater or less extent that are exempt.

On the first appearance of this disease, some five years ago, the gardener or farmer whose plants were mostly allowed to take their own course of growth attributed the rot to his own carelessness in neglecting to give his plants support and to keep them from contact with the damp soil. A year or two of experience has eradicated this notion, for some careful cultivators who always trained their plants and pruned away all superabundant foliage were almost as heavy losers by the disease as those who gave no special care to their vines.

The rot seems to be most destructive where the soil has been fertilized with unrotted stable manure. But one exception to this was noted, in a garden where the soil, a close clay, had not been manured for several years except in one spot, where the slops from the house had been thrown. Here the loss was about 20 per cent., and the disease lasted until well along in September. Tomatoes grown in old hot-beds are much more subject to the disease than those grown in ordinary garden soil; in fact, all the evidence which we have been able to gather leads us to believe that the use of fresh manure is almost certain to be followed by a severe attack of rot. At the time the disease first appeared in our garden, some five years ago, we were accustomed to manuring heavily every spring with stable manure only partially rotted, always pruning and tying the plants to branched stakes. The disease appeared when the first fruit formed, and continued until probably the first two fruiting clusters were cleared, then it ceased. This year, thinking the soil rich enough, we omitted to manure the ground, and as a result we had but one plant that produced diseased fruit, and this in a garden where the disease has held sway for at least four years. As to pruning or not pruning, we can not learn that it affects the case much either way, we believe, however, that pruning and tying to stakes or trellising is to be preferred in all cases to leaving the vines on the ground or even allowing them to run on brush or frames without pruning.

In this locality there has been little opportunity for determining the influence of atmospheric conditions upon the rot. The seasons have been mostly dry since its advent here, last summer (1887) exceptionally so, with a corresponding high range of temperature. What a really wet season might do for it we have had no means of estimating.

In the following notes on treatment what little has been learned has been acquired in a fortuitous way from observations of the varying conditions of environment and methods of culture, afforded by soil, location, and the various horticultural notions of different persons. Throughout this State no line of treatment has been undertaken, and the disease has been generally considered by the people as a mysterious dispensation of Providence and accepted with a certain amount of resigned inactivity born of a profound ignorance of the whole subject.

Our observations seem to indicate that soil containing fertilizing material in great excess of the demands of plant growth, and especially if it is in a state of active decomposition, greatly aggravates the rot. In view of this fact it is probable that by applying manure to the ground in the fall, using well rotted fertilizers and turning them under, the disease may in a measure be prevented. The application of ashes will not prevent it; and the throwing of slops on the ground, particularly if the soil is heavy, and not often stirred, seems to invite the attacks of the malady. An open, porous soil, rich in organic plant food that has already undergone decomposition, if kept stirred deep enough to thoroughly aerate it, offers but a poor abiding place for the fungus, and its attacks if made will be of short duration.

Respectfully,

H. S. BOWERS.

Hon. N. J. COLMAN.

3.—A DISEASE OF THE TOMATO.

(Plate IV.)

I.—GENERAL OBSERVATIONS.

In December last Mr. Marcius Wilson, of Vineland, N. J., sent to the Department for examination some diseased tomato leaves, and in a letter accompanying them he says:

I send you a small package of tomato leaves from our greenhouses. We have about 12,000 feet of glass, that have been devoted chiefly to winter tomatoes for several years past. The plants have already yielded, this month, several hundred pounds of beautiful ripe tomatoes, and more are coming on, but a peculiar mildew, which has troubled us some before this, now threatens to destroy the vines entirely. The lower leaves of the vines have always been more or less affected with apparently the same kind of mildew that is seen on tomatoes out of doors, but generally they outgrow it. The mildew under consideration attacks the leaves of the terminal shoots. It appears in small dark-colored spots, spreads rapidly, and affects the vigor of the plants much more than the other kind.

We have tried sulphur on the hot-water pipes, and have dusted it over the leaves, but without any apparent benefit. For the purpose principally of absorbing moisture and drying the atmosphere, we have also dusted lime very freely over the plants, but nothing as yet has served to check the spread of the mildew. We are now very anxious to learn more about the character and cause of the species of mildew I send you, and especially to find a remedy for it.

The larger part of the vines in the houses are more or less affected by the fungus seen on the large leaf from the lower part of the vines. This disease of the lower leaves has affected our plants for several years, but the peculiar dark spots on the terminals first made their appearance about three winters ago. Occasionally, especially late in the fall or early winter, a vine affected in its terminal shoots would show a black streak down the stalk for a foot or more, and large numbers of such plants would die in a short time. This season but few of the vines have died, but their growth has been seemingly checked. The plants have been kept very dry for several weeks past, and this has perhaps somewhat checked the development of the fungus, but now we do not see that abundant watering makes much change in the plants affected. A few weeks ago, during a light fall of snow, which lasted about twenty-four hours, the fungus spread rapidly, although the houses were kept about as warm as usual.

Replying to Mr. Wilson's queries, it was stated that the tomato leaves submitted for examination showed that the vines were suffering from the attacks of a fungus, named *Cladosporium fulvum** by Prof. M. C. Cook in 1883, from specimens sent him from North Carolina.

From an account of this fungus written by Mr. C. B. Plowright, and published in the *Gardeners' Chronicle*, October 29, 1887, it appears that in England the tomato vines have suffered from its attacks to a greater degree, even, than in this country. The fruit, as well as the foliage, is subject to the ravages of the parasite, and to illustrate how rapidly it may spread, Mr. Plowright makes the following quotation from a letter from one of his correspondents:

My plants have been very healthy all the year. On the 16th I noticed a few spots on the leaves here and there; on the following day (17th) I took a walk through the houses. On examining the foliage the spots were seen to be spreading very rapidly. By Monday morning, the 19th, to my surprise, every plant in the house was affected, but not many of the fruit showed it at this time. To-day (26th), however, I found several like the specimens sent herewith. I have about six hundred young plants in cucumber-houses for the winter. On looking at these closely this afternoon, I see that the disease is making its appearance in every house.

* *Cladosporium fulvum*. Cke. Grev. 1883, p. 32. *Effusum fulvum*, *lanosum*; hyphis erectis, flexuosis, septatis, nodulosis, parce ramosis, fulvis; conidiis ellipticis, unispatis, vix constrictis, pallide fulvis, hyalinis, 10-20 by 4.5 μ . In foliis lycopersici in Carolina Americæ Borealis. Ravenel, No. 599.

The tomato leaves submitted by Mr. Wilson very clearly show the appearance and effect of the disease on the foliage. Brownish, felted spots of irregular size and outline appear on the under surface of the leaves as a first manifestation of the disease: these gradually spread, at the same time corresponding points on the upper side assume a yellowish color. As the disease progresses the affected parts become dark-brown or nearly black, and as a final result of the action of the fungus the leaves shrivel and dry up.

II.—BOTANICAL CHARACTERS OF THE FUNGUS.

Under the microscope it is seen that the vegetative portion or mycelium of the fungus consists of delicate, colorless, septate threads: these are often found penetrating the tissues in all directions, and occasionally overrun the surface. The reproductive bodies or spores are borne upon erect branches which spring from the mycelium in dense tufts (Plate IV, Fig. 9). They vary considerably in size and shape, being oval or elliptical when full grown, 10 to 18 μ in length by 4 to 7 μ in diameter (Fig. 10). They are usually divided near the middle by a transverse septum or wall. They germinate readily in water or moist air by sending out one or more slender germ-tubes, which rapidly increase in length, soon developing into a mycelium like that from which they were derived (Fig. 10 d).

The hyphæ are, as a general thing, very irregular in length and diameter, and are often provided with tooth-like or swollen projections on the sides upon which a chain of from three to five spores are borne (Fig. 11 a).

According to Dr. Halsted* this fungus occurs abundantly upon the leaves of tomatoes grown in open air in the vicinity of Ames, Iowa. In 1883 some experiments were made at the latter place to determine, if possible, whether the spores from the leaves would, when sown upon the fruit, produce rot. Portions of the affected leaves were attached to healthy, green tomatoes; spores were removed with a knife and placed in a cavity of the stem, or on the blossom end, according to circumstances. Other tomatoes had a cross made in them with a knife just through the skin, while others with the skin cut in the same manner had the spores of the *Cladosporium* placed on the exposed tissues of the tomato.

In two instances the rot quickly followed the application of the spores to the green tomatoes while on the vines. In one case the decay was pronounced, the sowing having been made in a depression at the stem attachment, which was uppermost. The rot that appeared at this point soon destroyed the berry and spread to others in contact with it. The green, partly grown fruit that was removed and left without any treatment remained in a healthy condition for a long time. The tomatoes that were cut and not sown with any spores kept in good form, and the exposed surfaces quickly sealed over. The fruit with similar incisions and having spores from the leaves rubbed upon it, soon began to rot at the cut surface and was shortly decayed throughout. In like manner the tomatoes having two crosses began to decay at the incisions sown with the fungus, while those free from the spores dried on the surface and became healed over.

With our present limited knowledge of the habits of this fungus it is impossible to indicate any definite line of treatment. It is prob-

* Proceedings of the Society for the Promotion of Agricultural Science, 1883, p. 42.

able, however, that we may succeed in saving tomato plants grown under glass by spraying the foliage with a solution of sulphuret of potassium, one-half an ounce of potassium to the gallon of water.

To be effective this preparation should be applied frequently—say once every ten days—beginning when the plants are small and before they become crowded. In no case should the spraying be deferred until the fungus has made its appearance, as it will then be too late to produce any beneficial results. The fungus is more likely to attack plants under glass which have been subjected to sudden changes of temperature such as may be caused in winter by the fires becoming low or too much ventilation during cold, and especially windy weather. Care should be taken, therefore, to keep the temperature as nearly even as possible, and as tomatoes require considerable heat this is quite a difficult task, especially in the North.

4.—BROWN-ROT OF THE CHERRY.

Monilia fructigena, Pers.

(Plates V, VI.)

I.—GENERAL OBSERVATIONS.

Of all the diseases that affect the cultivated cherry the one here designated as Brown-rot is without doubt the most wide-spread and destructive. This malady occurs throughout the entire country, and the losses resulting from its attacks are frequently very great. From the information which we have been able to gather from various sources we infer that while nearly all fruit-growers are familiar with the effects of this disease there are few who know its cause.

Mycologists, however, have known for a long time that it is due to the presence of a minute parasitic fungus which, owing to its wide distribution, together with the fact that it occurs upon quite a number of pomaceous and other fruits, has received many names.*

The first account of the fungus worthy of note was published in 1879 by Von Thümen in his *Fungi Pomicoli*.† In 1885 it was again made the subject of a paper by W. G. Smith in the *Gardeners' Chronicle*,‡ and the same year Prof. J. C. Arthur published a detailed description of its habits in the fourth report of the New York Agricultural Experiment Station.§ It is held by some mycologists that it occurs only upon fruits which have previously been injured by insects or other agents, but careful investigations have shown the fallacy of this, for it is known that the parasite attacks not only sound and immature fruit, but often destroys leaves, flowers, and even young branches.||

* *Agrosporium fructigenum*, Pers., *Oospora candida*, Wallr., *Oidium Wallrothii*, Thüm., *Oidium fructigenum*, E. & K., etc.

† Page 23.

‡ Page 52.

§ Page 280.

|| Von Thümen (*Fungi Pomicoli*, p. 23) asserts that the fungus really possesses antiseptic qualities. According to his statement pears thoroughly covered with the fungus will remain for weeks upon moist ground without decaying, whereas those free from the parasite show signs of decomposition in the course of a few days when exposed to similar conditions. Hallier (*Wiener Obst- und Gartenztg.*, 1876, p. 117) explains this by assuming that the *Monilia* prevents the access of yeast fungi and other agents of rapid decay.

II.—EXTERNAL CHARACTERS.

On the flowers.—The fungus makes its appearance on the flowers soon after or about the time the petals fall. At first a slight discoloration appears at a given point; this rapidly increases in size until at length the entire flower assumes a brownish hue.

After killing the flower the fungus frequently attacks the pedicels where it produces similar discolorations to those described above. The dead flowers usually remain on the tree for three or four weeks, then if the weather is wet they begin falling, and as they consist at this time of a soft mass of rotten tissue they stick to any part of the tree with which they come in contact. Many fall upon the leaves and young fruit and become so firmly attached that no ordinary rain or wind will remove them (Plate V, Fig. 3 c c).

Careful experiments have shown that the rotting flowers are highly infectious, and that wherever they touch the leaves or fruit decay sets in.

On the leaves.—Here the presence of the fungus is first made manifest by a slight discoloration of the tissue around the point of infection; this gradually enlarges and at the same time the normal healthy green color changes to reddish-brown. The diseased spots are visible on both sides of the leaf, being, however, usually more distinct upon the upper surface. They have no regular shape and their outline is not, as a rule, sharply defined (Plate V, Figs. 1, 2). During wet weather the spots on the upper surface are frequently studded with little tufts of the fungus; these usually have a mealy or pulverulent appearance, and are easily washed off by rain or removed by the wind.

On the fruit.—As in the case of the leaves, the fruit is often infected by means of the diseased flowers. At first there appears a brownish circular spot on one side of the cherry; this rapidly enlarges and soon the entire fruit becomes brown, shrunken, and soft. Ultimately the stalk which supports the fruit is attacked, and finally the whole, the stalk and the fruit, either falls to the ground and dries up, or remains hanging on the tree throughout the summer, or, as frequently happens, until the following spring (Fig. 3 a). The fruit is often covered with tufts of the fungus similar to those occurring upon the leaves, and while in this condition they are highly infectious, causing all the fruit with which they come in contact to rot.

III.—BOTANICAL CHARACTERS.

The fungus consists of a vegetative portion or mycelium and spores or reproductive bodies.

Mycelium.—The mycelium traverses the tissues of the fruit, leaves, or flowers, as the case may be, in all directions, and under its action the external effects described above are produced. In addition to the cherry the mycelium was examined in the peach and apple. In the peach it is thin-walled, septate, of varying diameter, and its contents are filled with vacuoles (Plate VI, Fig. 4). This was found mainly between the cells, but in some cases it seemed to have penetrated them. The cells, however, were everywhere permeated with a very fine mycelium (Fig. 3), and in one or two cases this seemed to be continuous with the coarser kind.

In the fresh apple this coarser, thin-walled mycelium was also found, but in a dried specimen the appearance was totally different.

In the latter case the mycelium between the cells was very thick-walled, so that the contents appeared like a fine thread running through the center (Fig. 2) and not occupying more than one-sixth the diameter of the thread. The walls had a shining, white appearance, making the mycelium very prominent wherever it occurred. This was not seen in the cells, but both inside and outside there was an abundance of the fine mycelium already described, which has about the diameter of the contents of the large filaments, and walls that are scarcely visible.

Where the epidermis is separated from the tissue by the pressure of the stroma at the base of the fruiting tufts there is often a triangular empty space entirely around the stroma, and this space contains great numbers of these fine threads. The union of these with the coarser threads is shown by the fact that the latter may be seen to run out into the fine threads (Fig. 2 *b*). The transition is not gradual; the walls suddenly disappear and only the contents seem to be continued, but careful focussing will show that the walls are really present but so thin as not to be seen readily. In two cases what seemed to be the passage of the mycelium into the cell was observed. The appearance is shown in Fig. 2 *a*. Directly opposite the point where the coarse mycelium comes in contact with the cell wall is a small round hole just large enough for one of the fine threads to pass through.

The union of either the fine or coarse threads with the stroma was not followed out, but both are very numerous all around it. The stroma is composed at the base of thin-walled pseudo-parenchyma that merges into parallel threads having the same structure as the thin-walled mycelium of the fresh peach and apple. These hyphæ push up through the epidermis (Fig. 1), branch and diverge, and finally each bears a chain of spores; the chain of spores may also branch. The spores multiply from the end of the chain so that the terminal one is the youngest.

Spores.—The spores are one-celled, colorless, and filled with a granular protoplasm (Figs. 5, 7). Their shape differs a little on different hosts, but they may generally be described as oval. They germinate readily in moist air or water, producing a germ filament which is filled with a granular substance like the spores and contains occasional septa (Figs. 5, 6).

The germ-tubes from isolated spores often grow to a considerable length before branches are formed: this ultimately takes place, however, and by continual growth the tubes finally develop into a mycelium which does not differ from that found in the diseased tissues. When several spores in close proximity germinate, the tubes therefrom often coalesce with one another in the following manner: the tips of lateral branches sent out from the main tubes come in contact with each other, and where this occurs the walls of each disappear and the now united branches consist of a continuous tube holding the main filaments together (Fig. 5). Frequently a lateral branch comes in contact with the main tube from another spore, and in such cases the walls of each—the main tube and the branch—disappear and a complete union is thus effected.

The spores are capable of retaining their vitality for a long time; specimens collected in July, 1886, furnished spores which germinated in May, 1888.

Spores from cherries which had hung on the tree for a year germinated readily in moist air, and when sown upon the young leaves and

flowers they soon developed to such extent as to produce the characteristic discolorations.

In order to test the effect, if any, of sulphate of copper and liver of sulphur upon the germination of the spores, the latter were sown in solutions of these substances having various strengths. It was found that a one-fifth per cent. solution of copper was sufficient to prevent the spores from germinating. A one per cent. solution blackened and shriveled the spores to such an extent that they were scarcely recognizable. The copper solution seems to destroy the vitality of the spores entirely, as the latter rarely germinate after being exposed a very short time to the action of the substances. Liver of sulphur gave practically the same results as the sulphate of copper; some of the spores germinated in a one-fifth per cent. solution of this substance, and further investigation showed that very few developed in a one-twentieth per cent. solution.

IV.—TREATMENT.

A knowledge of the nature and habits of the fungus of brown-rot enables us to suggest several methods of combating it. In the first place the fruit killed by the parasite, whether cherries, apples, or peaches, should not be allowed to remain on the tree over winter as we have already seen that every one of the apparently lifeless fruits harbors many thousand spores. As soon, therefore, as the leaves have fallen all of the shriveled fruit should be removed from the tree and destroyed either by burning or burying. It would also be well to burn all the old leaves, twigs, and fruit that may have accumulated beneath the trees.

It is very probable that many spores of the fungus live over winter in the crevices of the bark, and in order to destroy these the trees should be sprayed in the spring, before the buds have commenced to expand, with a solution made by dissolving 4 pounds of sulphate of iron in 5 or 6 gallons of water. About the time the flowers are opening the trees should again be sprayed, this time using a solution of sulphuret of potassium, one-half ounce of the potassium to the gallon of water. A second application of this solution should be made at about the time the cherries are beginning to form, repeating the operation at intervals of two weeks until the fruit begins to color.

For applying the foregoing preparations a good force-pump fitted with spraying-nozzles is required. The Nixon pumps and nozzles manufactured at Dayton, Ohio, will probably be found as cheap and efficient as any in the market for this purpose. These machines, together with others designed for similar work, have been quite fully described by Professor Riley in a number of preceding* reports of this Department.

5.—THE POWDERY MILDEW OF THE CHERRY.

Podosphaera oxycantha (D. C.), DeBary.

(Plate VII.)

I.—GENERAL REMARKS.

Among the parasitic fungi which attack cultivated plants the powdery mildews or *Erysipheæ* hold a prominent place; the native vegetation is also much infested with them and it is very probable that

* Annual Report 1881-'82; Bulletin No. 10 Entomological Division, p. 57.

in many cases they have been transferred from the latter to the former. Like many of the members of this group the powdery mildew of the cherry attacks plants belonging to several genera, and it is also somewhat variable in its microscopic characters. These facts have led botanists to give it a number of names.

History.—It was first named and described by De Candolle,* who found the species on the hawthorn (*Crategus oxyacantha*) and called it *Erysiphe oxyacanthæ*. Later DeBary† with a different understanding of the genus changed the name to *Podosphaera oxyacantha*. Wallroth,‡ a German botanist, described the same fungus on the species of *Prunus* (cherry) as *Alphitomorpha trydactyla*, and De Bary§ afterwards made this name *Podosphaera trydactyla*. The form on the huckleberry (*Vaccinium*) was also described as distinct and named *Podosphaera myrtilina* (Schubert) Kunze. The form on *Spirea* was considered a good species and named *Podosphaera minor* by Howe.|| Earle, in a revision of the American forms of *Podosphaera* and a comparison of the European has shown¶ that all these belong to one widely variable species whose characters nevertheless are as well defined as several other species of the group. Still later Miss Martha Merry** demonstrated that the so-called *Microsphaera fulvofulera* described by Cook from California specimens on *Spirea*, is identical with the form on the same genus of host plants called by Howe *Podosphaera minor*. In the selection of the name for the species as a whole the oldest available name, *Podosphaera oxyacantha*, the one for the form on *Crategus*, was chosen.

Host plants and distribution.—This fungus occurs commonly in the eastern and central portions of the United States, and is reported from the Rocky Mountains and California.

Young cherry trees are the chief sufferers from its attacks, but it also does considerable harm to the peach and to young apple trees in the nursery, and occasionally seriously injures the quince. It is of very common occurrence, but fortunately does not usually get under headway until the trees have made their growth and are past serious injury. The fungus has been found on the following host plants, all of the order Rosaceæ, except the species of *Vaccinium* and persimmon:

Red cherry (*Prunus cerasus*), Garden plum (*P. domestica*), Wild red cherry (*P. Pennsylvanica*), †† Wild red and yellow plum (*P. Americana*), Small bird-cherry (*P. padus*), Sloe or blackthorn (*P. spinosa*, *P. demissa*), Choke cherry (*P. Virginiana*), Peach (*P. persica*), Apple (*Pirus malus*), Crab apple (*P. coronaria*), Quince (*Cydonia*), English Hawthorn (*Crategus oxyacantha*), Hardhack (*Spirea tomentosa*), Meadow sweet (*S. salicifolia*), Douglas's Meadow sweet (*S. Douglasii*), Shad-bush (*Amelanchier Canadensis*), Blueberry (*Vaccinium myrtilus*, *V. uliginosum*), Persimmon (*Diospyrus Virginiana*). ††

* Flore Franc., VI, p. 106.

† Beitrage III, p. 48.

‡ Flore Crypt. Germ., III, p. 753.

§ Beitrage III, p. 48.

|| Bulletin of Torrey Botanical Club, V, p. 3.

¶ Botanical Gazette, IX, p. 24.

** Botanical Gazette, IX, p. 189.

†† Found by the writer on this host in Illinois, September, 1898.

‡‡ Rose, J. N. Botanical Gazette, XI, p. 61.

II.—EXTERNAL CHARACTERS.

The disease has been observed in Missouri as early as the 1st of June,* but usually it does not develop sufficiently to attract attention until July. During the latter part of summer and autumn it reaches its greatest development. It is first noticeable on the young leaves and tender shoots as small, round, or irregular, whitish blotches having a radiated appearance. The spots soon spread and run together, covering indefinite portions of the foliage or more often running over the entire leaf. As the fungus spreads the radiated appearance disappears. The threads meantime branch profusely and cross each other in all directions, forming an even white felt which may be very thin or so dense as to entirely conceal the green color of the leaf. The denser portions then become covered with a whitish powder, and still later the threads give rise to minute, black, spherical bodies just visible to the naked eye. The fungus grows on both sides of the leaf, in some cases indifferently on either surface, but usually a decided preference is shown for but one. On one tree the upper side of the leaves will be badly infested while the under side will have scarcely a trace of it; another tree, perhaps in the same orchard, and only a few feet away, will be badly mildewed on the under side with little on the upper. Frequently the black spherical fruits of the fungus are found abundantly on the leaves, usually the under side, with only a very scanty development of the white threads. From this condition very little damage results to the plant, and it does not present the characteristic mildewed appearance. Probably in this instance the leaf is pretty well matured before the fungus attacks it. On the other hand the principal damage to fruit trees results from the attacks on the growing tips and young leaves. Here the coating of the fungus is usually quite pronounced and the mealy appearance mentioned above is most prominent. This most destructive form of the fungus usually bears but a few of the spherical spore cases and often fails to produce any before frosts put an end to the season's growth.

III.—BOTANICAL CHARACTERS.

The white felt which creeps over the surface of the leaves is the vegetative portion or plant body of the parasite. It consists of slender, branching, septate, white threads, and is termed the mycelium. These filaments are about 4μ * in diameter. They do not penetrate the host, but send down small suckers, called *haustoria* (Fig. 5), into the epidermal cells. The fungus is entirely destitute of chlorophyll and depends wholly on the plant upon which it grows for its support. The haustoria absorb the juices from the host cells and transmit the material to the mycelium where it is used in the development of the fungus. As the development of the parasite proceeds certain rather thick branches called *conidiophores* arise from the mycelium and assume a vertical position. A transverse partition forms near the end of a branch, and the cell so isolated becomes somewhat rounded, and finally falls off. The spore thus formed is called a conidium (Fig. 4 *c d*). In the mean time similar partitions have been forming successively from the end of the filament downward, so that conidia occur in all stages of formation and give to the conidiophore a moniliform appearance (Fig. 4).

*Galloway.

*One μ = $\frac{1}{25000}$ of an inch.

Some of the conidia reach a suitable place for germination and start the fungus in a new place. As the conidia are exceedingly small they are carried about by currents of air or by insects to adjoining trees.

These spores serve for the rapid spread of the fungus during summer. Later in the season, usually during summer, the dark colored spore-bearing bodies called *perithecia* develop at points where two filaments cross. Like the seeds of higher plants their development is the result of an act of fertilization.

The young sporocarp or perithecium is colorless, or nearly so, but as it grows larger it becomes yellowish, finally brownish, and when mature it is very dark brown or nearly black and opaque.

The fully developed perithecium (Fig. 1) is spherical when viewed from above, but the side toward the leaf is much flattened, so that the object represents slightly more than half a sphere. The surface is covered with numerous reticulations which indicate the cells of which it is made up. Each cell is rounded outward, so that the perithecium is covered with hemispherical protuberances or blunt conical projections. From some of the cells of the upper part of the perithecium arise peculiar outgrowths or appendages, characteristic of the *Erysipheæ*. They are septate, that is, consist of several cells, the lower of which are tinted brown while the upper and longer cell is colorless. This ends in a peculiar dichotomously branched tip (Fig. 2). While many of the appendages are highly developed and several times branched, others have this character but slightly developed, or entirely wanting, and end in a blunt point. The appendages vary in number from eight to twenty; sometimes there are only three or four. They are usually arranged in a circle around the upper part of the perithecium, but are sometimes clustered at the top and extend upward in an oblique direction. The perithecium contains a single, large, transparent spore sack (Fig. 3 a) called an *ascus*, in which may be seen eight elliptical ascospores (Fig. 3 b). With the exception of the thin places in the walls of the asci at each end there is no provision for the escape of the spores except by the breaking up of the perithecia the following spring from decay.

Little has been ascertained concerning the germination of these spores or the processes by which the fungus first starts on the leaf.

In many of the specimens examined small bodies were found resembling perithecia, but more delicate, thinner walled, lighter colored, and made up of smaller cells (Fig. 6). These are not of a constant size or shape, but were usually ovate or elliptical, and under pressure discharge from the apex numerous small elliptical spores (Fig. 6). They were supposed for a long time to be a part of the fungus, that is, one kind of its spore-producing bodies, but are now known to be a parasite on the mildew. We have here, then, a case of a parasitic fungus growing on another parasitic fungus. This parasite was first discovered by Cessati, who found it in connection with the grape mildew, and called it *Ampelomyces quinqualeis*? This opinion was overruled and the fungus was considered one of the fruiting forms of the mildew until DeBary investigated it and demonstrated that it was a parasite on the mildew and not a part of it. DeBary named it *Cincinobolus Cessatii*. It occurs on various species of *Erysipheæ*, and was found quite commonly on the specimens of *Podosphera* examined. In one instance a leaf supposed

to be covered with the perithecia of *Podosphaera* showed upon examination only the smaller, lighter-colored perithecia of *Cincinobolus*. In many instances it doubtless greatly prevents the spread of the mildew.

Conditions favoring the development of the fungus.—The members of this family thrive best during warm, dry weather, and the species under consideration seems to be no exception to the rule. In the Mississippi Valley vegetation suffered greatly from drought during the years 1887 and 1888, and in consequence the mildews had an unusual opportunity for development. In the latter year the cherry fungus was very abundant in Illinois, doing considerable damage to young trees. A light rain, giving the conidia a chance to germinate, followed by a long, dry spell, is probably the best time for the fungus to develop. On the other hand seasonable rains and other conditions favoring the proper growth of vegetation are probably the conditions least favorable to the parasite. It is a question whether the greater development of the mildews during a dry season is due to the direct action of these conditions on the fungus itself, or whether the explanation is to be found in the weakened vitality of the host. Both these influences must probably be taken into account. Plant parasites, however, have a way of appearing very abundantly in certain seasons and in certain places without any evident reason.

V.—TREATMENT.

On account of their manner of growth, which as we have seen is almost entirely on the outside of the leaves, the powdery mildews are easily reached and destroyed by fungicides. So far as we are aware no experiments have been made with the view of finding a remedy for the species under consideration, but as the powdery mildews are much alike in their structure and mode of growth it is reasonable to suppose that the treatment would be similar for all.

Sulphur, as is well known, has been successfully used in the treatment of the powdery mildew of the grape and rose, and it would no doubt be a successful remedy for this species. The material must be in a finely powdered condition and be dusted over the diseased parts.

From the numerous liquid fungicides the following have been selected as most suitable for use in this case, principally on account of their success in combating the mildew on the grape and rose. They are recommended in the order in which they are given, and should all be applied to the plants in the form of a fine spray.

Sulphuret of potassium (Potassium sulphide).—Simple solution in water. About one-half ounce to the gallon. Experiments conducted by the Section this year (1888) show conclusively that this remedy will not only prevent the powdery mildew of the grape but will destroy it when under headway. At the New York Agricultural Experiment Station during the present year Mr. E. S. Goff has found it successful in the treatment of the gooseberry mildew.

Liquid grison.—Prepared by boiling 6 pounds of sulphur and 3 pounds of lime in 6 gallons of water until the whole is reduced to 2 gallons. Allow to settle; pour off the clear liquid and bottle it until used. For use mix one part of the liquid with one hundred parts of water.

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6.—LEAF-BLIGHT AND CRACKING OF THE PEAR.

Entomosporium maculatum, Lév.

(Plates VIII, IX.)

I.—GENERAL OBSERVATIONS, ETC.

During the past year the Section has received many inquiries concerning a disease long known to horticulturists as "leaf-blight" or "scald" of the pear tree. It is quite distinct from the ordinary "pear-blight" and affects the fruit and wood as well as the leaves. It is extremely destructive in some parts of the country and merits special attention.

Effects and losses.—In this connection some extracts from correspondence may be of interest.

Letter from W. W. Thompson, Smithville, Ga., May 28, 1888:

The trees (Le Conte) are five years old and 15 feet high, set in a circle 15 feet in diameter containing twenty-one trees. Nearly all the leaves have dropped from one-third of the trees, yet the wood looks sound and green. I find the disease is extending round the circle.

Ibid., July 24:

So far the disease is limited, though I find it more extensive now than a few months previous. It has extended to a slight degree to my regular orchard. On some trees a portion of the lower leaves have fallen, and in several cases several limbs are as bare as in the fall, but, as I have said, this is only to a limited extent.

Ibid., October 31:

The spotted leaves have increased very much since I first wrote you. The fruit is not injured nor are the trees to any extent except in growth and appearance. Last year I did not notice it at all here but did in Thomasville, and I have been there this summer and find it on most of the trees in the town, more than in the country. Some were nearly leafless in August. * * * The young leaves within 12 inches from the end of the limb do not seem to be affected. * * * Trees about towns and homes seem to be the worst, though I have seen even the center of my orchard affected; in fact all the trees are diseased to some extent, but most of them on the lower leaves only. When badly affected the leaves fall two months or more too early.

Letter from Mr. F. S. Earle, Cobden, Ill.:

The premature falling of the leaves due to the attacks of the Leaf Blight fungus often causes great damage. I have seen an orchard of 3,000 Louis Bonne trees as bare by the 4th of July from this cause as they should have been by Christmas. The fall rains brought out a new set of leaves, and such fruit buds as were already formed bloomed, thus destroying the chances for a crop the following year.

Letter from Col. A. W. Pearson, Vineland, N. J., October 25, 1888:

The leaves have all fallen except those of the Kieffer pear. * * * Other varieties of pear infested with the disease are denuded of their leaves fully six weeks be-

fore frost. * * * I think that with those sorts worst affected the damage in this region amounts to 75 per cent. It is an injury difficult to estimate, as the trees are denuded prematurely of their leaves, and then, of a late autumn, they are apt to open a premature bloom, and this detracts from the crop of the ensuing year.

The statements comprised in these letters show that the disease exists with different degrees of severity in different localities, but they are unanimous in indicating that fruit growers have much to fear from the malady, and that prompt treatment is necessary. Seedlings are particularly subject to the attacks of the disease; in fact many nurserymen have been forced to entirely abandon the culture of pear stocks on account of it.

Hosts.—The disease is not confined entirely to the pear, although it is on this that it most concerns farmers and fruit-growers. It also attacks the *Cydonia* (quince), *Cotoneaster*, and *Mespilus*. Nearly every variety of the pear is subject to it, but some are more liable to its attacks than others.

Mr. F. S. Earle says that "out of an experimental orchard of a hundred and twenty varieties planted at Cobden, Ill., all but ten or twelve were so badly injured as to be discarded as worthless." In a letter, from which we have before quoted, Col. A. W. Pearson says: "The Kieffer seems to best withstand the fungus. * * * The varieties most damaged are the Sheldon and Beurre Clairgeau. Both of these have been an entire loss for four years past. Every fruit has shriveled and cracked." In quotations already made from letters of F. S. Earle and W. W. Thompson, it is evident that the Le Conte and Louis Bonne are also very liable to attacks. From our own observations we conclude that Louis Bonne, Bartlett, Seckel, Bosc, Clapps, and Roestiezer are never entirely free from the disease and are usually badly attacked, while Anjou, Duchess, Lawrence, Flemish, and Vicar may be mentioned among the varieties most exempt.

Geographical distribution.—As has already been shown the pear and the fungus have nearly the same distribution. The disease has been reported on various hosts from Germany, Sweden, Italy, and France, and in this country it is very wide-spread.

History.—It was first discovered by Chaillat on living leaves of *Cotoneaster tomentosa* and *Mespilus germanicus*—two plants related to the quince and pear—and named *Xyloma mespili* by DeCandolle. Morthier afterwards found it on the first-named plant, also on *Pirus communis* and *sylvestris*, and Fuckel found it on *Cotoneaster vulgaris*. Fuckel gave it the name *Morthiera mespili*, including the fungus as found on all the above named hosts, and by this name it is still generally known. Saccardo, however, published only the form on *Mespilus germanicus*. Ellis and Cooke on the other hand founded the variety *Cydonie*, occurring on quince leaves and fruit, upon Fuckel's *Morthiera mespili*. Lévêille changed the genus to *Entomosporium* and made two species, one *Entomosporium maculatum*, including the form on *Pirus communis*, and the other *Entomosporium brachiatum*, comprising the fungus on *Cotoneaster* and *Pirus sylvestris*.

In his *Sylloge Fungorum*, Saccardo attempts to reconcile these conflicting authorities as follows: He includes under *Entomosporium maculatum*, Lév., on *Pirus communis* the following varieties: (a) *domesticum*, equal to his former species (*Morthiera mespili*, Sacc.) on *Mespilus germanicus*; (b) *cydonia*, E. & C., on quince; and he changes *Entomosporium brachiatum*, Lév., to *Entomosporium mespili* (DC.).

The two species are founded merely on a difference in size of the

spores. According to Fuckel the conidia measure 14 by 18 μ . Sorauer gives the largest spores on *Pirus communis* as 22.5 by 10 μ , and Saccardo gives the following:

E. maculatum, conidia 18-20 by 12; pedicel, 20 by $\frac{1}{2}$ μ .

var. *domesticum*, conidia 18 by 8; pedicel, 15 by $\frac{1}{2}$ μ .

var. *cydoniae*, conidia 12-15 by 6-7 μ .

E. mespili, conidia 25 by 15; pedicel, 20 by $2\frac{1}{2}$ μ .

A careful comparison of these measurements will arouse some doubt as to their value as a basis for establishing species. Fuckel's and Saccardo's measurements might indicate some constant differences in size between the two species, but Sorauer's measurement of 22.5 by 10 μ on *Pirus communis* does not fall much short of Saccardo's 25 by 15 μ on *Pirus sylvestris*, and according to Saccardo's own measurements there is more difference between the species *E. maculatum* and its var. *cydoniae* than the two species *E. maculatum* and *E. mespili*.

Furthermore, measurements of spores from the cultivated pear, made in this Department, indicate that their size may exceed the largest measurement given by Saccardo for *E. maculatum*. In fact, the founding of species on the size of spores, especially when the differences are so slight as in the present instance, needs repeated observations and measurements under varying conditions before much dependence can be placed upon it; and this is one case where the required number of observations have not yet been made. In fact, even if the variations given prove to be constant, it still remains to be proved whether they are not due simply to a change of host. The question is an extremely practical one, for, if farmers must expect infection from sources outside their own and their neighbors' pear trees, it is necessary that they should know it.

In Europe the fungus has been known for nearly a century. De Candolle mentions it in 1815. In this country the injury resulting from the disease has been discussed by fruit-growers for many years. In "Barry's Fruit Garden" for 1863 the author, in speaking of the difficulty connected with the growing of pear seedlings, says:

This difficulty is owing chiefly to a species of rust or blight that attacks the leaves of the young plants, very often before the latter have completed their first season's growth. * * * It appears on the leaves in July or August first as small brown spots: these spread rapidly over the leaves until they are completely dried up and growth is stopped. Whether it is an insect or fungus, or some atmospherical cause, that produces this blight is unknown. Certain causes favor one or the other of these opinions. More minute investigations are wanted on the subject.

II.—EXTERNAL CHARACTERS.

The disease makes its appearance early in the spring soon after the development of the leaves. It first shows itself in the shape of small, dull, carmine-red spots which appear first on the upper, and finally penetrate to the lower surface of the leaf; the color soon changes from red to a dark brown, with a slightly elevated, minute, black spot in the center (Pl. VIII, Fig. 1). The spots also increase in size, and if they are very numerous, as is most often the case, the tissue between them also turns brown and loses its vitality. If the leaf is young or belongs to a delicate leaved variety it shrivels up by the contraction of the diseased portions; but if it is mature and consists of firm tissue it retains its shape, the only change being in the color. As soon as the leaf becomes badly diseased it falls off; and if, as often happens, another growth of leaves is produced, these too

become diseased. The spots are usually about three millimeters in diameter.

Trees seriously attacked by this disease can be distinguished at a distance by their defoliated appearance. This wholesale destruction of the foliage interferes very seriously with the growth of the wood and the maturing of the fruit, for the leaves are the organs which transform the food material that is brought up from the roots and absorbed from the air, into a form in which it can be directly used by the plant in the making of wood and production of sugar in the fruit.

But, in addition to this, the fruit and stems themselves often become diseased. The fruit also shows the carmine-red spots, which afterward become dark colored. The skin becomes very much roughened, and the growth of the epidermis over the diseased portion is checked, causing a crack which extends deeply into the flesh (Fig. 2), so that, even if the fruit can obtain sufficient sugar to mature properly its appearance is spoiled, and the cracking makes it liable to decay.

The development of the fungus on the branches does not differ materially from what takes place on the leaves. There first appear small circular spots on the young bark; these gradually become elongated and somewhat depressed with a slight elevation in the center, and their color changes to a shining, brownish black. Frequently the stem is completely girdled by these diseased areas, and as a result the end of the branch dies above the point where the fungus is present. The petioles and leaf scales are also often diseased. Indeed there seems to be no part of the tree above ground that is in active growth quite exempt from the attacks of the parasite.

III.—MICROSCOPIC CHARACTERS.

The small black specks in the center of the brown spots comprise the fruiting portions of the fungus. The fruit is at first covered by the cuticle, but this is finally ruptured exposing a layer of spores borne on a thin stroma (Plate IX, Fig. 1). The spores or conidia are analogous to the seed of higher plants; they have an exceedingly characteristic form, and may always be recognized without difficulty. When mature, they consist of from four to six cells, and are borne upon a pedicel or stalk. Their development is as follows (Fig. 2): short branches consisting of three or four somewhat elongated cells grow up from the stroma. The upper cell first shows an enlargement and this is followed by the second one which usually constitutes the lowest cell of the conidium, the remaining ones forming the pedicel. From the upper one of these cells grows out a fine, upright bristle which is about the length of the cell itself. It has distinct walls and contents, as may be seen by staining with iodine. Before these two cells are fully developed small buds may be seen growing out on the lower one, close to its point of contact with the upper. These vary in number from one to four. They grow out obliquely, so that they are in contact with the upper cell. In size they are much smaller than either of the others. From these in turn there grow out bristles, but in this case the bristles are on the backs of the cells and are directed horizontally, or obliquely. Occasionally three cells of the original filament swell up to form the conidium, and in this case both the lower cells may bear buds, or the lower one may branch and bear another conidium, so that one pedicel bears two conidia.

When the conidia germinate the cells enlarge somewhat and the bristles swell up at the base; the colorless, and sometimes septate, germ-tube frequently emerges in the vicinity of the bristle. When germination takes place on a leaf the germ-tube bores through the epidermis and develops a mycelium within the tissues.

The mycelium is composed of short cells forming colorless branching filaments. It is very abundant and is everywhere easily seen between the cells of the body of the leaf (Fig. 1). When young it penetrates the epidermal cells only, but Sorauer says that when it is old it becomes darker colored and can be seen within the cells of the mesophyll; and Ericksson states that he has found Sorauer's observations true in every respect. The mycelium masses itself together in places between the cuticle and epidermis, forming a thin stroma on which the conidia are borne. Below the stroma the mycelium seems at first to pass mainly between the epidermal cells, but it finally breaks them down so completely that the walls and contents can with difficulty be distinguished. The cuticle is finally ruptured by the pressure of the stroma and young spores, and the conidial layer is exposed to the air. Sorauer says that on August 4, 1876, the upper surface of the leaves of five one-year old pear seedlings were inoculated with these conidia and placed in moist air under bell jars. Three of the inoculated leaves, on two plants, showed the characteristic circles at the points of inoculation August 19, and a conidial pustule in September, giving about a month for the complete circle of reproduction.

In addition to the conidia Sorauer has also found what he considers the ascosporous or winter stage of the fungus (Fig. 6). The following is abridged from his account:

An investigation of the diseased leaves in December will disclose brown capsules on the tissues in addition to the still living conidial layers. These capsules (perithecia) I consider as the fruit of *Morthiera*, which attains maturity in May and June. The perithecia vary considerably in size. They are dark brown, globose or depressed from above, usually solitary, sometimes in groups of several ranging from 75μ to 175μ , and in some instances to 200μ in diameter. They are usually found either on the upper surface between the separated palisade cells or between these cells and the epidermis. In the first case they are not recognizable on the outside. In the latter there is a distinct swelling caused by the epidermis being lifted up by the growth of the capsule. The brown wall of the capsule varies in thickness, the greatest width being about 7.5μ . In January the best developed perithecia contain at their bases a mass of white, stromatic, small-celled tissue, from which arise numerous nearly upright, slender threads ranging from 1.5μ to 2.5μ in diameter. These are the young asci.

The asci are club-shaped, with a double contour, much the largest in the upper third of their length, and contain eight colorless, crowded ascospores, in two rows (Fig. 6 a). They are somewhat shorter than the paraphyses, and at maturity are obtusely conical in the upper portion, the point being drawn out into a papilla. This projecting point opens, forming a circular aperture through which the spores are discharged one after another (Fig. 6 b).

The paraphyses arise in a tuft from the base of the capsule; they are filiform to club-shaped or globose at the apex (Fig. 6 e), and are occasionally borne in pairs on one pedicel.

The spores are acute ovate to obtuse club shaped, divided into two parts by a transverse septum sometimes slightly curved and somewhat constricted at the partition (Fig. 6 a). When seen in large numbers the ripe spores have a pale, yellowish-brown appearance. They sometimes germinate while still in the ascus. In germination the hypha usually proceeds from the smaller end (Fig. 6 c d).

Their germination was observed in May at about the time the first diseased spots appeared upon the new foliage. So that if the conidia fail to carry the fungus over winter, or if they do not find a lodgment on the young stems, the ascosporous fruit will pass the winter unharmed and be ready to begin its work with the unfolding of the leaves.

Sorauer further classifies the fungus as a *Stigmatea* and gives it the specific name of *mespili*.

So far as known to us this has not been verified by any other observer.

There are several other fungi found associated with the *Entomosporium* on the pear and quince, and prominent among them is the one figured on Plate IX, figs. 4, 5. It is frequently found on the same spots with *Entomosporium*, but is often quite separate from these spots; it is especially frequent where the leaf is so badly diseased that the tissues are nearly all dead.

At first this appeared so closely connected with the *Entomosporium* that it seemed as if it might be the spermogonial form, but a closer examination revealed morphological differences in the mycelium. That of the spermogonial form is darker colored, thicker walled, contains distinct globules, and is not so closely septate or abundant. Moreover, this form is often widely separated from the conidial form of the *Entomosporium*. It is probably saprophytic in its nature, coming on the leaf after the *Entomosporium* has killed it. These capsules are found alike on both sides of the leaf, but more often on the upper side. They consist of a single layer of dark colored pseudo-parenchyma, lined with a little colorless tissue on which are borne chains of minute rod-like bodies (Fig. 5). These are so small that they partake of the Brownian movement.

IV.—TREATMENT.

It is difficult at any time to treat large trees, but as this fungus causes the greatest injury to young ones, and especially those growing in nurseries, a course of treatment that would be of use in the latter place alone would be of great value. From what we know of the life history of the fungus it is evident that burning the fallen leaves would serve as an important means of removing a source of infection. With regard to the proper time to do this it is probable that the best results will follow if the leaves are raked together and destroyed as soon as they fall; in other words, it would not be advisable to allow such leaves as may fall in midsummer from the effects of the malady to remain on the ground under the trees until the following autumn or spring. They should be destroyed as quickly as possible, before any of the spores have had an opportunity to escape.

Patrick Barry,* speaking of this disease, says:

To obviate the difficulty which this malady presents [in the nursery], a vigorous growth should be obtained early in the season. New soil or that in which trees have not before been grown should be selected—an old pasture is the best. The autumn before planting it should be trenched or subsoil-plowed to the depth of 2 feet, for the pear has long tap-roots, and liberally enriched with a compost of stable manure, leaf mold, or muck and wood ashes in about equal parts; 4 inches of this spread over the surface before plowing, will be sufficient for ordinary soil. Lime should also be given liberally unless the soil be naturally and strongly calcareous. A soil prepared thus in the fall will require another plowing or spading in the spring to mix all the material properly with the soil and fit it for the seeds. If the soil be very tough, and not fit to be turned up, a thorough harrowing or working with the horse hoe will do. Where large quantities are grown the drills may be the same distance apart as that recommended for apples, 3 feet; but if only a few, 12 to 18 inches will be sufficient as the cleaning can be done with the hoe. The seeds should be scattered thinly, so that every plant may have sufficient space without any thinning. The end to aim at, as

* *Fruit Garden*, p. 127, revised edition.

before remarked, is to get good growth, say 18 or 20 inches in height and stout in proportion, before the 1st of August. This can be done in any deeply trenched or plowed fresh soil, well prepared and manured, as described above. I have been told that seedling pears grown in a frame covered with whitewashed sash and kept well ventilated continually escaped the "leaf-blight," whilst all those grown in open ground near by were blighted.

In addition to the foregoing it is very probable that the development of the fungus upon the leaves or other parts of the plant may be prevented by the application of some fungicide, although no experiments having a bearing upon this question have, as far as we know, been undertaken. Since the spots make their appearance as soon as the leaves have attained full growth the applications must be made early so as to prevent the spores from germinating. In no case should the application of the remedial agents be postponed until the fungus has made its appearance upon the leaves, for if this is done it will be of little use to apply them.

Where the disease prevails more or less every year it would be well to thoroughly spray the trees, before the buds begin to swell, with the Bordeaux mixture, prepared as follows:

Dissolve 16 pounds of sulphate of copper in 22 gallons of water; in another vessel slake 30 pounds of lime in 6 gallons of water. When the latter mixture has cooled pour it slowly into the copper solution, care being taken to mix the fluids by constant stirring.

When the leaves are about two-thirds grown a second application should be made, this time, however, using a solution containing the ingredients in the following proportions:

Sulphate of copper	pounds..	6
Lime	do....	6
Water	gallons..	22

Dissolve the copper in 16 gallons of water and slake the lime in 6 gallons, then mix as described above. For applying these preparations an apparatus including pump, spraying-nozzle, etc., is necessary, and for small trees, especially those in the nursery, the machine known as the Eureka Sprayer, manufactured by Adam Weaber, of Vineland, N. J., will be found as efficient as any. With this machine a man can rapidly and thoroughly spray trees from 12 to 14 feet in height, but for large trees a pump having greater power will be required.

The object of the first spraying is to destroy any spores of the fungus that may have survived the winter in the crevices of the bark, while the second and weaker application is obviously for the purpose of preventing such spores as may fall upon the young leaves from germinating. It would be well to repeat the applications of the weaker solution every three or four weeks until the last of July or middle of August. The same preparations mentioned above may be used to protect the leaves of seedling pear trees against the ravages of the parasite, but in this case the first application of the Bordeaux mixture, second formula, should be made about the middle of June, followed by a second two weeks later, and a third the latter part of July. If this course of treatment is properly carried out we have little doubt that the plants will preserve their leaves throughout the season, and thus be able to complete their growth, making good stocks either for budding or grafting.

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7.—LEAF-SPOT OF THE ROSE.

Cercospora rosæcola, Pass.

(Plate IX.)

I.—GENERAL OBSERVATIONS.

This disease is quite distinct from the one that is generally known as black-spot, caused by the *Actinonema rosea*, but it may occur on the same bush and even on the same leaf. Like the *Actinonema* it produces black spots on the leaves, and a superficial observer might consider it as the same disease, but a critical examination will bring to light very distinct and characteristic differences.

It is not generally so destructive to cultivated roses as the black-spot, but seems to prefer hardy kinds, especially the climbing species and varieties. This year it was very abundant on the wild roses in the vicinity of Washington. In many cases half of the leaves were affected and would fall to the ground when the plants were shaken. On the roses in the Department grounds, however, it was not present to any injurious extent.

Several years ago this fungus attacked about 2,000 large "Baltimore Belle" and "Queen of the Prairie" roses (climbers) growing in a nursery at Columbia, Mo., and by the middle of August nearly all the leaves had fallen. These plants, however, had not been pruned for two years, and had become so thickly matted together in consequence that the sun could reach only the outside leaves and branches. In September they were cut back to within 3 feet of the ground, the trimmings and leaves were burned, and the ground between the rows plowed and harrowed. The following year the leaves remained healthy throughout the summer. This was probably due to two causes: first, the removal of a source of infection by burning the diseased leaves, and plowing the ground so as to bury the spores that were scattered over the surface; second, the severe pruning allowed the sun and air currents to reach all parts of the plants, and

consequently they were probably kept too dry to allow the germination of any spores that might remain upon or be brought to them.

We have never observed the fungus on plants under glass except in the summer, when the sashes were removed.

II.—EXTERNAL CHARACTERS.

The disease first makes its appearance in the form of black or reddish black spots (generally the black shades into red at the edges); as the spot increases in size the center becomes light brown or even grayish. The reddish color usually remains at the edges. In the autumn the spots frequently remain small and the entire leaf becomes variegated with red and yellow.

The spots of *Actinonema* are always black from the beginning, and if the tissue around changes color it is to yellow or brown, not red. The spots of *Actinonema* are frayed at the edges while those of *Cercospora* are definite. Besides this, the center of the *Cercospora* spots often appears as if sprinkled with a white powder; this is not true of the *Actinonema*.

III.—MICROSCOPIC CHARACTERS.

This white appearance is caused by tufts of upright hyphæ which bear numerous whitish elongated spores. The tuft is represented in Plate IX, Fig. 7, with spores attached. These hyphæ or sporophores are brownish, borne on a stroma or rather knot of mycelium, and are frequently zigzag at the free end. The spores are long, septate, larger at the end where they are attached, and varying in length at different seasons (Fig. 8).

They are at first borne upon the end of the sporophore, but this grows out, leaving them a little behind and giving rise to another spore at the end. This process may be repeated, and each spore is left upon a notch at the side of the sporophore, giving the zigzag appearance already referred to.

The mycelium passes between the cells, and when a fruiting tuft is about to be formed a few threads push up between the epidermal cells and send out short upright hyphæ that rupture the cuticle. The stroma at the base continues to grow, and it finally pushes apart and breaks into the epidermal cells; the short sporophores meantime elongate and bear spores.

In the fall and upon wild roses the spots often remain quite small and seem to be perfectly sterile, but a section reveals that in many cases the fruiting tufts are immature, the cuticle is ruptured but the hyphæ have not elongated, and the stroma is not large enough to force the epidermal cells apart. Whether these immature hyphæ bear spores has not been ascertained.

IV.—TREATMENT.

A hint as to the method of treatment has already been given in the first of this article, and from the instance given there it would appear as if severe pruning, burning all diseased parts, harrowing the ground, and the choice of an airy, dry situation might be sufficient to avoid any serious consequences from this disease.

8.—PLUM POCKETS.*

Taphrina pruni, (Fekl.) Tul.†

(Plate X.)

I.—GENERAL OBSERVATIONS—HISTORY.

During the summer of 1888 the attention of the Section was several times called to a disease affecting the fruit of the cultivated plum. Letters were received from correspondents living in various parts of the country, stating that upon certain trees there were formed, instead of the normal plums, peculiar hollow deformities, consisting merely of a thin shell, with no evidence whatever of a seed. Specimens of these malformations were received from South Carolina,† Ohio, Kentucky, Kansas, and other States, with statements to the effect that upon many trees not a healthy plum could be found.

This disease is due to the presence of a parasitic fungus which attacks the young fruit, and by its growth within their tissues causes the peculiar development of the latter which finally results in the formations of the so-called "pocket."

It is evident that such remarkable growths as are produced by this fungus must have attracted the attention of both scientific men and practical fruit-growers long before the true cause of the trouble was known or even suspected. As long ago as 1593 an author by the name of Casalpin described the malady; but he offered no explanation as to its cause.

History.—For a long time the malformations were believed to be due to the work of insects;§ later it was suggested that improper fertilization might be the cause, and still more recently it was held that an abundance of moisture in the atmosphere, especially while the fruit was forming, would produce the deformities.

* A number of names have been applied to these malformations by horticulturists, but the one here adopted is probably more generally used in this country than any other. In France the disease is known as "Lepre du Prunier." In Germany the pockets are called "Narren," "Shorten," etc., and in England "Plum Pockets" or "Bladder Plums."

† Synonyms:

Exoascus pruni, Fekl. Enumeratio Fungorum Nassoviæ, p. 29; No. 189.

Ascomyces pruni, Berk. Annals et Magaz. Nat. Hist.

Taphrina pruni, (Fekl.) Tul. Annales des Sciences Naturelles: ser. v, Tom. 5; 1866, p. 129.

‡ A correspondent from this State writes as follows concerning this disease: "I send you by this mail several diseased plums which I think have been stung by an insect. About nine-tenths of the fruit on one of my trees are affected like the specimens communicated. The tree which produced these monstrosities is of the Chickasaw type; two common wild plums grow quite near the diseased one, but their fruit is perfectly sound." (May 21, 1888.)

§ From the *Magazine of Horticulture*, Vol. VIII, 1842, p. 247, we quote the following from an article by Dr. T. W. Harris, author of several important entomological works. "Last year," writes Mr. Harris, "an undescribed disease of the plum made its appearance in some gardens of this vicinity, in the latter part of the month of May, and has been observed again during the present season. Soon after the blossoms had fallen the fruit began to swell rapidly, and in the course of two or three weeks it had grown to more than ten times the size that it ordinarily attains in the same period. It was soft and compressible, as though it were pulled up with air, being filled with an elastic, spongy substance of a whitish color. In some of these inflated plums no vestige of a kernel remained: in others, a little, soft, and empty shell was found. After growing from one-half to more than three-quarters of an inch in diameter the fruit dropped, and by the middle of June no more of it was to be seen on the trees.

"The cause of this puffy swelling of the fruit, and abortion of the kernel, is a little thrips; and several of these minute insects were found on the 28th of May on almost all the diseased plums. It is possible that they began their attacks in the blossom,

The real cause of the disease was discovered in 1861 by Fuckel, a European mycologist, who described the fungus under the name *Ecoascus pruni*.^{*} Three years later it was more thoroughly studied by DeBary, whose discoveries † concerning its life history have been verified by a number of subsequent writers on plant diseases. ‡

For a number of years the fungus retained the name given it by Fuckel, but by a later classification it became *Taphrina pruni*, (Fckl.), Tul. §

II.—EXTERNAL CHARACTERS, LOSSES, VARIETIES AFFECTED.

The "pockets" (Fig. 1 *a*) make their appearance soon after the flowers have fallen, attain full size and drop from the tree toward the middle or last of June. At first they are more or less globular in shape, but as they grow older they become oblong or oval and frequently more or less curved. They vary in size, but as a rule are from 1 to 2 inches in length and from one-half to 1 inch in diameter. When young they are nearly smooth and can be distinguished from the healthy fruit by their pale-yellow or reddish color. As they grow older the color changes to gray, the surface appearing as though it had been sprinkled with fine powder, and at the same time the pockets become wrinkled. Finally they turn black or dark brown, and rattle like bladders when brought in contact with any hard

and that they prevent the impregnation of the ovule or young kernel by destroying the pollen; and by subsequently puncturing the plum, produce an irritation which is followed by a rapid swelling and diseased condition of the fleshy substance of the fruit. Prematural enlargements and distortions of the parts of flowers and of fruits are known to be occasioned by the attacks of other species of thrips. This may be seen in the blossom of the black whortleberry (*Vaccinium resinolum*), all parts of which, calyx, corolla, stamens, and ovary, are sometimes enormously enlarged, and entirely changed in texture and appearance, in consequence of the punctures of a kind of thrips.

"It is not yet known how far this affection of the plum has extended. In this vicinity it seems to have been confined to certain trees only. Should the insects multiply and spread to other trees and other places, they will prove very destructive to the fruit hereafter. It remains therefore for the practical gardener to watch for their first appearance, and to devise some sure means of killing them, while the trees are in blossom and the fruit is forming."

^{*} *Ecoascus pruni*, Fckl. Sporidia eight, ovate or irregular, hyaline; asci erect, subclavate, obtuse; paraphyses three times shorter than the asci, irregular, hyaline. Densely covering the epidermis of the immature fruit of *Prunus domestica*. *Enumeratio Fungorum Nassoviæ*, 1861, p. 29.

† Beitr. zur Morphologie und Physiologie der Pilze, 1864, p. 33.

‡ See Bibliography.

§ The genus *Taphrina* has lately been made the subject of a paper by Mr. B. L. Robinson (*Annals of Botany*, Nov., 1887), who, in speaking of its synonymy, says: "The species combined by Sadebeck, in 1883, into a single genus, were formerly classed in three closely related genera *Taphrina*, Fries. *Ascomyces*, Mont. et Desm., and *Ecoascus*, Fuckel. Of these genera the first is the oldest, having been described by Fries as early as 1815 under the name of *Taphria*, which, to avoid possible confusion with an insect genus, was altered in 1825 to *Taphrina*."

"In this paper just mentioned Sadebeck has preferred, although without stating his reasons, to retain for the combined genus the youngest of the three names, that of *Ecoascus*, Fuckel. Johanson agrees with Sadebeck in thinking that all the species should be combined into a single genus, but, seemingly with much more regard for the rules of priority in nomenclature, retains the name *Taphrina* of Fries. There appears to be all the more reason for this from the fact that, as early as 1866, Tulasne (*Super Friesians Taphrinarum Genere*, in *Ann. des Sciences Nat.*, ser. 5, Tome V, 1866, p. 122) revised the genus of Fries and expanded its limits so that it might take in all the species then known of *Ascomyces* and *Ecoascus*, thus using the name *Taphrina*, so far as the knowledge of the time enabled him, in the same sense as it is at present employed. From these considerations it seems best to follow Johanson in calling the group '*Taphrina*, Fries, char. a Tulasne emend.' a sort of nomenclature which, if not brief, is yet in accord with priority and incapable of being misunderstood."

substance. They remain on the tree in this condition for two or three days, then fall to the ground and perish.

Sections through the diseased fruit show that the walls are quite thick, and that in place of a stone there is a large cavity filled with fungous threads and air.

The fungus often attacks the young branches and leaves, and when this occurs the injury is of course much greater than where the fruit alone is attacked. According to Mr. A. A. Crozier the fungus was abundant on the College farm at Ames, Iowa, the past season, attacking wild cherry (*Prunus serotina*) and several cultivated varieties of the wild plum (*Prunus chicasa*), being most prevalent on a vigorous grower and light bearer known as Maquaketa. Mr. Crozier further states that in his section it occurs mainly on the growing branches and leaflets, which become contorted and greatly swollen in consequence. About the time of the completion of the season's growth in June the diseased branches turn gray and the parts soon soften, then dry up and die. Shoots which arise the following year just below these dead extremities are most frequently affected by the disease.

So far as our observations have extended, the disease is never widespread in its effects; that is to say, it never sweeps over the country attacking all varieties of the plum alike, but on the contrary it often happens that a particular tree will bear nothing but "pockets," while adjacent trees of the same variety, grown under precisely the same conditions, show no traces whatever of the disease. It is difficult, therefore, to estimate even approximately the amount of injury the parasite occasions, but enough is known concerning its ravages to fully demonstrate its gravity.

As a rule a tree that has once borne a crop of the "pockets" seldom recovers, but continues with each succeeding year to produce a greater or less number of the malformations. All plums are more or less subject to the attacks of the parasite, but it is usually more abundant on the red and purple varieties. It also occurs in this country upon the wild red plum, *Prunus Americana*; the beach plum, *Prunus maritima*; the dwarf cherry, *Prunus pumila*; the wild black cherry, *Prunus serotina*; and the choke cherry, *Prunus Virginiana*.

III.—BOTANICAL CHARACTERS.

A microscopic examination of one of the diseased plums will show that the fungus occurring within the tissues consists of three parts, namely, (1) mycelium; (2) asci; (3) spores or reproductive bodies.

The mycelium or vegetative portion consists of colorless, septate filaments, which may first be seen in the soft bast of the fibro-vascular bundles that penetrate the flesh of the fruit. They multiply at first in the tissues of the "pockets," and afterwards pass towards the surface. Some of the hyphae push up between the epidermal cells and spread out between these and the cuticle. Here by repeated branching and interlacing they form a net-work which is not more than one cell deep (Figs. 2, 3). The threads forming this net-work are composed of very short cells, not more than twice as long as broad, which soon start an independent growth at right angles to the surface of the pocket, forming small cylinders standing close side by side, but apparently unconnected (Fig. 4). They at first carry the cuticle upon their ends, but finally rupture it and appear on the surface. These bodies are the immature asci. They are at first filled with a rich granular protoplasm, which, as they increase in length, passes into their free ends and is cut off from the rest of the tube by a septum.

The portion above is now the ascus proper, and occupies about two-thirds of the length of the tube, the remainder constituting the pedicel. The protoplasm now rounds itself off into several, usually eight, spores (Fig. 6). These are colorless, globose, and about $4\ \mu$ in diameter. The mature asci are club-shaped, 40 to 60 μ long by 8 to 16 μ in diameter. They stand closely side by side, the pedicel supported upon the upper surface of the epidermal cells so that no part of the asci extends within the tissues.

The spores escape when ripe by rupturing the free end of the ascus. They germinate readily in water by the formation of an excrescence or bud, which soon assumes a shape about like that of the parent spore. The daughter spore in turn gives rise to a second bud like the first, and this process continues for several generations, or until the nourishment in the fluid is exhausted. If mature spores are detained within the ascus germination frequently follows, and as a result the latter becomes filled with innumerable sprouts of various orders and sizes, which readily separate and escape as individual spores when the ascus is ruptured.*

From the foregoing facts it is seen that the fungus is abundantly able to propagate itself. Each "pocket" develops countless numbers of asci, and each ascus, as a rule, contains no less than eight spores, which upon germination give rise to several generations of daughter spores. Notwithstanding the ease with which the spores germinate, no one has succeeded in infecting healthy plums with them.

The mycelium of the fungus is found in the smaller branches in early spring before the diseased fruit appears, which seems to indicate that it may live from year to year in the tree itself; moreover, the annual recurrence of the "pockets" on the same tree furnishes additional proof of this fact.

The only course of treatment which a knowledge of the facts in the case suggests is to remove and destroy the "pockets" before they reach maturity. In doing this, it would seem to be well to cut back the branches so as to destroy all the parts which are likely to contain the mycelium of the fungus. Instances have come under our observation where this practice was followed for two or three years with decidedly beneficial results.

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*De Bary: *Morph. und Biologie der Pilz.*, 1884, p. 289.

9.—APPLE RUSTS.*

(Plates XI, XII.)

I.—GENERAL OBSERVATIONS.

Orchard rusts have long been known as troublesome pests to the apple, quince, and other cultivated fruits, often doing much injury to the crop. It is not the present purpose to enter into a discussion of the destructiveness of these fungi, but assuming that their eradication is desired the allotted space will be occupied in outlining the present knowledge of the rust plants and suggesting remedies which have borne the test of trial, or may, in the light of a fuller understanding of the fungi, prove of advantage in diminishing their inroads upon an important industry.

As now understood, the apple rusts are forms of species of the genus *Gymnosporangium*, which live upon the cedars or junipers (*Juniperus* and *Cupressus*) in one stage and upon the apple in another. These two forms in the life history of the parasite are so very different in outward appearance that the early botanists classified them as distinct species in different genera. Those upon the cedars, as above stated, are *Gymnosporangia*, and the forms upon the apple are members of the old genus *Rastelia*. As the condition upon the cedar precedes that upon the apple, in the cycle of life of the fungus, it is proper that we first confine our attention to the form upon the juniper group.

The genus *Gymnosporangium* is a member of the group *Uredinea*, or true rusts, to which, also, belong *Puccinia*, *Uromyces*, *Phragmidium*, and a number of less-known genera, as well as the old form-genera *Uredo*, *Æcidium*, etc. The order *Uredinea* is one of parasites, and many of them are particularly destructive to farm and garden crops. We have only to point to the wheat, oat, rye, and barley rusts, and those of many grasses and other crops, to convince the general reader that the groups to which his attention is called is one abounding in injurious species. An outline of the life history of the wheat rust may help in explaining the meaning of the term *form-genus*, and at the same time prepare the way for a more thorough understanding of the cycle through which the apple rusts pass.

The rust of the wheat was first named *Uredolinear* and described as a distinct species. A rust upon the barberry was designated *Æcidium berberidis*, and another form of fungus upon the wheat was styled *Puccinia graminis*. Tulasne, thirty years ago, advanced the idea that the *Uredo* species were only early forms in the development of species of *Puccinia*. In 1863 De Bary† added the belief that the *Æcidium* species, so called, were likewise forms in the life history of *Puccinia*, *Uromyces*, and allied genera, and that they preceded the *Uredo* stage. De Bary's view was based upon a very careful study of the wheat rust. The spores found late in the season upon the wheat culms, and appearing as dark-brown patches, were germinated, producing small spores upon the tips of minute filaments. These sporidia De Bary found would not grow, except upon the leaves of

* By Byron D. Halsted.

† Recherches sur le développement de quelques champignons parasites.—Ann. des Sc. Nat., 4, Ser. 1-20.

the common barberry, where they vegetated and produced in a short time the true barberry rust (*Æcidium berberidis*). The spores are borne in cups grouped together; hence the common name of "cluster cup" for the fungus. When the spores contained in the cups find their way to the blades of wheat, germination, quickly follows; the slender threads called mycelia or hyphae penetrate the plant and there vegetate. In a short time a yellowish patch is produced, and the imbedded fungus by rupturing the epidermis exposes the orange dust characteristic of the wheat rust. Following the *Uredo linearis* is the final state, or *Puccinia graminis*, the one with which De Bary started.

It will be seen to follow from the pains-taking investigation of the celebrated German botanist that what were called distinct species become only forms of the same species, and were all the life histories of the various kinds of rusts known, it is probable that such genera as *Uredo* and *Æcidium* would cease to remain. They are retained to accommodate those forms, the genetic relationship of which has not as yet been determined. In deciding upon the name for the polymorphic fungus it is natural to select the final form; therefore, in case of the examples here briefly outlined, the species is *Puccinia graminis*, Pers., which includes all the stages. A common method of indicating the *Æcidium*, *Uredo*, and *Puccinia* (teleutosporic) forms is by Roman numerals. Thus whatever in the description of the species comes under I refers to the *Æcidium* state; under II to the *Uredo*, and III represents the final form.

Let us now glance at some of the distinguishing characteristics of the three forms above mentioned. The final spore formation called the teleutospore, in *Puccinia graminis*, as in all members of the genus *Puccinia*, is composed of two cells, usually very closely united by their bases and spoken of as a single spore. It is virtually a winter condition of the species, with the protoplasm condensed within and surrounded by thick protecting walls. These cells germinate in any moist place in spring, producing a slender filament usually somewhat branched, and finally bearing a small spore upon each tip. This first form of spore is not ranked as a distinct state, because it is simply the escaped condition of the vital substance of the teleutospore in a shape to facilitate the multiplication and easy dissemination, as well as penetration into the host of the essential part of the teleutospore. The *Æcidium*, as seen upon the barberry leaf, assumes in its full development a cup like structure with wall and contents. The portion of leaf which is infested is somewhat thicker than the normal parts, often of a yellow, orange, or even reddish color—and in this thickened patch develop the aecidia or cups. These form within the infested substance, and only become cup like when they rupture the epidermis, and the exposed end of the wall breaks irregularly and the edges turn outward, thus forming the minute cup, within which the multitudes of aecidial spores are borne in closely-packed rows, and upon this account are often quite polygonal. In the early stage of the development of this fungus in the infested portion of the leaf there are minute oval or flask-shaped organs called spermatogonia, produced usually upon the opposite side of the leaf to that finally bearing the cups. Small oval bodies are produced within the spermatogonia, but their function is not known—the conjecture has been simply that they take part in a process of fertilization not yet discovered. The most recent paper upon the

wheat rust is by H. Marshall Ward,* with excellent illustrations, which, with the classic contribution of De Bary previously cited, will give the interested student a full knowledge of the present aspect of the subject. In the Uredo state, upon the grass the fungus has no wall or cup consisting of its own tissue, but is made up of masses of threads which congregate under the epidermis, finally bursting it and exposing the elliptical, finely spinose, orange spores, borne singly and terminally upon long, slender stalks.

These uredospores quickly germinate and become the centers of mycelial growth for the production of pustules containing the final or teleutospores which, in their general method of formation from the hyphæ and the rupturing of the epidermis, agree closely with the uredo-form, except that they are not easily detached from their pedicels.

Having thus purposely repeated the essentials in the life history of a leading member of the genus *Puccinia*, the careful reader is prepared to enter upon a more elaborate treatment of an allied group of species.

II.—THE GENUS GYMNOSPORANGIUM.

This genus is in some respects closely related to *Puccinia*. These two, out of several genera in the group *Uredineæ*, are the only ones, for example, which have the teleutospores as a rule two-celled, as shown at Fig. 4 in Plate XII. The chief differences are in the time of year when the teleutospores are formed and the presence of a gelatinous surrounding to the spores. The pedicels or spore-bearing stalks are usually hyaline, more slender, and much longer in *Gymnosporangium* than in *Puccinia*, a necessary difference due to adaptation to the unlike conditions.

History of the genus.—The genus was founded by De Candolle in 1805.† Four years later Link‡ made a division based upon the shape of the gelatinous substance, placing those with cylindrical masses in *Podisoma*. This division was long retained, but is now generally considered as unnecessary. Of the nine species of the genus now known in the United States all are parasitic upon a small group of the *Conifera* or subfamily, the *Cupressineæ*.

Two species are confined to the white cedar (*Cupressus thyoides*); three inhabit exclusively the red cedar (*Juniperus Virginiana*); two have both of the above cedars for hosts: one upon common juniper (*Juniperus communis*) and one upon *Juniperus occidentalis* of the Rocky Mountains. All but the last are treated of, and with a master's hand, by Dr. Farlow,§ to whom the writer is under special obligations for matter used in this paper.

Characteristics of the species.—The species are founded upon the size, color, and approximation of the gelatinous, sporiferous masses, and the measurements, septa, color, number, and position of promycelia produced from each spore cell, and the character of the distortions of the host plant. The promycelia are the filaments which grow from the spore cells when they undergo the process of germination. At Fig. 5 in Plate XII is shown a teleutospore undergoing

* Illustrations of the structure and life history of *Puccinia graminis*, the fungus causing the "rust" of wheat.—Annals of Botany, Vol. II: p. 217; 2 plates.

† Flore Française, Vol. II.

‡ Observations in Ordinis plantarum, 1809.

§ The Gymnosporangia or Cedar Apples of the United States, from Memoirs Boston Soc. Nat. History 1880.

germination. A promycelium proceeds from each cell, and, branching, bears sporidia upon the tips.

The size of the gelatinous masses varies greatly among the different kinds. In most of the species the fungus is perennial and usually of a slower growth than with those living for a single year. This may account in part for the characteristic differences, for the hyphæ or vegetative threads of all the species are in themselves very much alike. Thus, in a slow-growing species with a small amount of mycelium there would naturally be less distortion for the same length of time than in a quick-growing annual species with a large percentage of mycelium within the tissue of the host. But even this attempt at an explanation does not render it clear why two species made up of almost indistinguishable filaments in equal amounts, and growing at the same rate over equal periods of time, should give rise upon the same tree, or branch of the tree, to widely different distortions of the host. In some of the perennial species the fungus lives mostly in the cambium layer and stimulates an excessive deposition of wood from year to year in the infested part until it becomes several times larger than the normal portion above and below the excrescence. Of such are the conspicuous swellings upon the branch of white cedar caused by *G. bisepalum*, Ellis. In others the mycelium spreads rapidly through the young twigs, robbing and dwarfing them until a dense tuft results unlike the healthy twigs of the cedar. The fanciful name of "Witches' Broom" is not inaptly applied to such distortions produced by *G. Ellisii* (Berk.), Farl. Other species are more local in their attacks and confine their work to a small cedar leaf, and the result is one of the so-called "apples," often soft in texture, due to the large percentage of hyphæ and the rapid growth of the gall-like structure. The response of the cedar plant to the stimulus induced by the young fungus is, perhaps, not unlike that following an insect's sting, and one is about as easy to explain as the other. The gelatinous, sporiferous masses vary greatly in size, color, and their proximity to each other. In *Gymnosporangium Ellisii* they are quite minute, almost invisible when dry, and of a reddish brown color, orange after a rain, when they are swollen by the moisture to nearly a quarter of an inch in length and scattered over the larger twigs composing the "broom-like" distortion. In *G. bisepalum*, above cited for its knotty excrescences sometimes several inches in diameter, the gelatinous, spore-bearing masses are borne in the cracks and fissures of the distorted stem as rugose, shapeless tufts of light yellow jelly. Other species have the spore-bearing, gelatinous outgrowths from the excrescence proper projecting for a considerable distance, often more than an inch, when swollen by prevailing moisture. In such there is a striking difference between the expanded form and the dry condition when the horns of jelly have dried down and almost disappeared.

Injury to the hosts.—All of the species of *Gymnosporangia* are injurious to the hosts but not in the same degree. It is not the most conspicuous species that necessarily effects the greatest injury. For example, a showy, rapidly growing annual may do less harm and be more quickly eradicated than a persistent, deeply seated perennial. If the destructive work of the species was confined to the cedars of various sorts there would be no serious complaint, but because in one form they trespass upon the apple, quince, and other closely allied cultivated plants, they are dreaded by the fruit-grower under the common name of "Orchard Rusts."

III.—THE ROESTELIA FORMS.

With this preliminary treatment of the first form of the species of *Gymnosporangia*, let us pass to a brief consideration of the second state, worse than the first; after which an injurious species is to be taken up for special inspection. The old genus under which the orchard rusts were classified by early botanists is *Roestelia*. This corresponds with and is not very different from the genus *Aecidium*, which was treated of while considering the polymorphic nature of *Puccinia graminis*, and known commonly as the "cluster-cup" form, growing upon the barberry. The chief difference is in the size of the wall (peridium) of the cup, which in *Aecidium* is short, while among *Roestelia* it is prolonged into a tube often several times as long as broad. In some species of the latter genus the cups or "horns" do not produce a fringed mouth at the top as is usual in *Aecidium*, but the cells of the peridium remain closed at the apex, and below separate from each other longitudinally, forming meshes for the escape of the spores.

These prolonged cups are borne usually in clusters upon the under side in thickened patches of the infested leaves or fruit of various pomaceous species of the order *Rosacea*, as for example the apple and quince. Some species frequently attack the young fruit and twigs and in developing greatly distort them. This is particularly true of *Roestelia aurantiaca*, Peck., which infests several species of hawthorn (*Crataegus*), juneberry (*Amelanchier*), and apples and quinces. This is a very beautiful species having brilliant orange spores, suggesting the specific name, and when growing in a large succulent fruit is usually attractive to the eye, if one can overlook the damage that the fungus has wrought. Quinces have frequently been seen of more than half their natural size and almost entirely covered with the densely aggregated broad cups which bear their shining white peridia, curved and exhibiting the masses of bright orange spores within.

The leading points in the classification of the *Roestelia* are gross appearance of affected parts (Plate XI, Fig. 1), location, size, form, color, and proximity of the aecidia; color, size, and markings of the spores and peridial cells, and location, number, and color of spermogonia.

The first indication of an attack of *Roestelia* is a slight discoloration of the part, usually the leaf, followed by minute flask-shaped bodies, the spermogonia filled with minute free cells of unknown use. Soon after, usually upon the opposite side of the leaf, appear the aecidia which bear the spores (Plate XII, Figs. 2, 3) that when returning to the *Cupressinea* develop the *Gymnosporangium* and thus complete the cycle of the fungus. As before stated, this relationship between the fungi upon the *Pomae* and the *Cupressinea* was long ago suspected, but not until within a few years has the actual demonstration been furnished. Dr. Farlow was among the first in this country to take up the work in a systematic, scientific manner.

In "the *Gymnosporangia*, or cedar apples of the United States,"* he recognized eight species of the genus *Gymnosporangium* and an equal number of *Roestelia*, but was at that time unable to fully establish the genetic relation between the two forms.

In February, 1885,† he concluded that *G. bisectatum*, Ell., and *R. botryapites*, Schw., were probably connected; also *G. globosum*, Farl., and *R. aurantica*, Pk., and that *G. macropus*, Lk., had its *Roestelia* on apples and *Amelanchier*.

* Memoir I. c. Boston Soc. Nat. History, 1880.

† Notes on some species of *Gymnosporangia* and *Chrysomyxa* of the United States. Am. Acad. Arts and Sc.

There are two chief means of gaining information upon questions of relationship in the forms of parasitic fungi; first, by studying with great care the geographical range of each form, and secondly, and most conclusively of all, by cultures. For example, if there is any considerable territory over which only one *Gymnosporangium* flourishes, and is followed by a single form of *Rastelia*, it would not be unfair to suspect, at least, that these two forms were of the same species. Such facts as these have given strong hints to aid in the systematic culture of the forms. The time of maturing the spores also enters as evidence of no small value.

Thus, *R. botrypites* upon the *Amelanchier* is late in maturing, scarcely being ripe before October, while the cedar apples of *G. macrospus* begin forming in early summer; therefore at the outset there is circumstantial evidence against these forms being genetically related. In this connection, however, it must not be forgotten that most *Gymnosporangia* are perennials and that the same may be true of the *Rastelia*. Consequently the only entirely satisfactory method of determining the relationship is by culture, and this consists in growing certain *Rastelia* upon the hosts and failing to grow all others, by repeatedly sowing the *Gymnosporangium* spores, under favorable conditions, while at the same time preventing access of any other kind of teleutospores.

Mr. R. Thaxter, a graduate student under Dr. Farlow, has been successful in this experimental work, and now with considerable confidence the connection between several species of *Gymnosporangia* and *Rastelia* can be stated. Without attempting to give the details of Mr. Thaxter's paper* the summary of results is here repeated:

1. *G. conicum*, D C.=*R. cornuta* (Ehr.), Fr.
2. *G. clavipes*, C. & P.=*R. aurantiaca*, Pk.
3. *G. clavariæforme*, D C.=*R. lacerata* (Sow.), Fr.
4. *G. macrospus*, Lk.=*R. pirata* (Schw.), Thax.
5. *G. biseptatum*, Ell.=*R. botrypites*, Schw.
6. *G. Ellisii*, (Berk.) Farl.=*R. transformans*, Ell., probably.
7. *G. globosum*, Farl.?

If we construct another table giving the hosts for each form, as has been done by Professor Seymour,† it would indicate new points of interest:

1. <i>G. Ellisii</i>	} White cedar	<i>Pirus arbutifolia</i>	} <i>R. transformans</i> 1.
2. <i>G. biseptatum</i>		Cultivated apple	
		Juneberry	<i>R. botrypites</i> 2.
		?	
3. <i>G. globosum</i>	} Red cedar	Mountain ash	} <i>R. cornuta</i> 4.
4. <i>G. conicum</i>		Juneberry	
		Hawthorn	
5. <i>G. macrospus</i>	} Crab apple	Cultivated apple	} <i>R. pirata</i> 5.
		Juneberry	
		Hawthorn	
		Juneberry	} <i>R. aurantiaca</i> 6.
		Quercus	
6. <i>G. clavipes</i>	} Red cedar	Cultivated apple	}
		and	
7. <i>G. fuscum</i>	} Juniper	?	} <i>R. lacerata</i> 8.
		Hawthorn	
8. <i>G. clavariæforme</i>	} Juniper	Juneberry	
		Wild and cultivated apple	

*On certain cultures of *Gymnosporangia*, with Notes on their *Rastelia*. Am. Acad. Arts and Sci., 1886, p. 259.

†Orchard Rusts, Vol. IV Am. Hort. Rept.

Among the *Cupressineæ* it will be seen that the red cedar is the favorite host, no less than four species infesting it. Of the *Pomaceæ* the juneberry takes the lead with five species.

At least four species may infest the cultivated apple, namely: *R. transformans*, a form of *G. Ellisii* on white cedar (*Cupressus thyoides*), *R. aurantiaca*, of *G. claripes* on red cedar (*Juniperus Virginiana*), *R. lacerata* of *G. clarariaforme* on juniper (*Juniperus communis*), and *R. pirata* of *G. macropus* on red cedar.

This should be borne in mind while we treat in detail of *G. macropus*, which is the species credited with causing the principal part of the rust of the apple orchard.

IV.—GYMNOSPORANGIUM MACROPUS, LK.*

This species (Plate XI, Fig. 2) is the common "cedar apple" of the United States, and during moist weather in spring produces conspicuous orange galls.

History.—It was first described by Schweinitz in 1882 as *Gymnosporangium juniperi-virginianæ*. In 1825 Link named it *Gymnosporangium macropus*, he having previously (1809) constructed the genus *Podisoma* to include those species possessing the gelatinous, sporiferous masses more or less conical or cylindrical. There is seemingly no good reason for his excluding this species from his new genus. In 1831 Schweinitz adopted Link's specific name, accepted his new genus, and called the species *Podisoma macropus*, Schw., by which name it has been generally known until within the last few years. Recent mycologists have considered that the mere shape of the gelatinous tufts is not generic, and being convinced that Schweinitz's original specific name was awkward and misleading, as four other species grow upon *Juniperus Virginiana*, by common consent the name here employed has been agreed upon. Schweinitz had himself already adopted Link's specific term.

Geographical distribution.—This species is found with its host over a wide range of territory, but not in equal abundance, wherever the red cedar grows. The introduction of the juniper into new localities has been followed by this parasite, so that the "apple" may be generally considered a quite constant accompaniment of the cedar.

External characters.—The "apple" or gall usually forms a somewhat kidney-shaped excrescence, attached by a small base on the concave side, and varying in size from a half an inch to an inch and a half in length. A careful search will reveal the first beginning of the enlargement some time in midsummer, much depending upon the weather previous to this time. The fungus attacks the leaves, and after vegetating for a time, develops a small external swelling of the size of a pin head upon one side. This continues to enlarge until the normal dimension is reached. A fully developed "apple"

*Synonyms:

Gymnosporangium juniperi-virginianæ, Schw. Syn. Fung. Carl.: Sup., p. 74; No. 504; 1822.

Gymnosporangium macropus, Link. Sp. Plant: Vol. VI: part 2, p. 128; 1825.

Podisoma juniperi-virginianæ, Fr. Syst. Myc.: Vol. III: p. 57; 1832.

Podisoma macropus, Schw. Syn. Fung. Am. Bor.: p. 307; No. 3096. Sprague's Contrb. N. E. Mycol., p. 329. Curtis Pl. N. C.: p. 121. Peck's 23d N. Y. Rept.: p. 57.

Eusiceata: Ravenel Fung. Car. 1; No. 85. Ellis N. A. F., 3; No. 270. Thüm. Myc. Univ.; No. 148.

seems often to be an outgrowth from the branch and frequently appears terminal upon the twig because the stem above it was crowded to one side or dwarfed and lost from view. When winter sets in these excrescences are of nearly full size, of a beautiful light chocolate color, and exhibit a uniform series of shallow pits.

Microscopic characters.—At this time the gall, in thin sections, under a high magnifying power is seen to consist of a mass of oval, thick-walled cedar cells packed together in an irregular manner, and ramifying among them are the hyphae of the fungus. During the early spring, when moist warm weather comes, the threads of the "apple" congregate at the base of each of the circular disks, each thread developing a double spore upon its tip, at the same time secreting a large amount of jelly and pushing out a horn of orange-yellow, elastic, gelatinous substance (Plate XI, Fig. 2).

At this time the galls are most conspicuous, and the cedar trees when badly infested appear, after an April and May shower, as if in bloom, and, in fact, the soft excrescences are commonly known as "cedar flowers." While these horns are extended and before having dried down by fair weather the teleutospores (Plate XII, Fig. 4) undergo the process of germination (Fig. 5). When the gelatinous masses become shrunken by drying, the sporidia, formed upon the tips of the promycelia (Fig. 5 *a a*), are brought into a condition to be easily removed and carried away by the wind. When another rain comes new spores mature and undergo the same process of secondary spore formation. After the season's crop of spores has been produced the excrescence becomes almost as hard as bone, and soon loses its attachment to the tree. In other words, the *Gymnosporangium* with which we are now more especially concerned is an annual. The galls may remain upon the branches for more than one summer, but only as dry and dead knots after the first year, and the retention is merely accidental.

Conditions favoring the development of the fungus.—The time in the spring for the maturing of the spores is largely determined by the weather. This may be illustrated by citing some experiments carried forward two seasons ago. The galls were gathered upon April 12, and, before any gelatinous tufts were developed, placed in water in a warm room; and on April 23 the sporidia were ripe and in great abundance. By this artificial heat and constant supply of water the fungus was forced at least three weeks ahead of its time. There is no doubt that a cold, dry spring retards the development of the cedar apple as much as opposite conditions tend to push it forward. In 1887 there were two distinct crops of the *Ræstelia* upon the wild crab (*Pirus coronaria*) on the college grounds (Ames, Iowa) as a result of natural sowing. There were practically two spring rains after the *Gymnosporangium* was sufficiently advanced to take advantage of moist weather, namely, on April 22 and 23, amounting to 1.26 inches of rain-fall, and June 12 and 13, amounting to 1.59 inches, with only .86 inch distributed among seven showers between the above dates. The sowing following the April rains matured the crops in fifty-eight days. Such a remarkable season rendered it easy to test the length of time required for the growth of the *Ræstelia*, as well as illustrated the fact of successive crops, the number of which would be determined by the number of rains and periods of dry weather during the weeks when inoculation was possible. It is also a matter of observation that the inoculation of the cedar tree for a

new crop of the *Gymnosporangium* in midsummer is dependent upon the character of the weather. A dry summer is not conducive to an abundant "seeding," while August showers favor the parasite.

V.—RÆSTELIA ON APPLES.

The *Ræstelia* associated with the large conspicuous annual *Gymnosporangium* (*G. macropus*) above described is *R. pirata* (Fig. 4) as given by Mr. Thaxter.

This was first described by Schweinitz as *Æcidium piratum* growing upon *Pirus coronaria*. It is recorded also upon the junberry and various sorts of cultivated apples. There has been a great deal of confusion in this *Ræstelia*, due to a variety of forms which it probably assumes. Dr. Farlow and Mr. Thaxter, both of whom have given much attention to this subject, are not convinced as to the exact relationship of the various forms of *Ræstelia*, especially the ones associated with *G. macropus*. It does not become me, therefore, to attempt the clearing away of doubts, which can only be done by a long series of cultures of all the species and their forms, both with the teleutospores upon the *Pomea* and the *Ræstelia* spores upon the *Cupressineæ*. Volume VII, part 2, of Saccardo's *Sylloge Fungorum*, just at hand, does not throw as much light upon American species of *Gymnosporangia* as might be desired. The author, Dr. J. B. De Toni, gives but eight species, and only one (*G. clavaria form*) with its *Ræstelia* upon *Pirus malus* (cultivated apples) and for *G. macropus* mentions only *Pirus coronaria* (wild crab) as the host of its æcidial form. It may be said in passing that *G. Ellisii* is *Phragmidium Ellisii*, Körn, but its relationship to *Ræstelia transformans* of the genus *Pirus* is fully recognized. It is, however, not the province of this paper, prepared as it is for the popular reader, to enter into a more extended consideration of the genetic relationship than a treatment of the remedial measures will warrant.

Characteristics of the Ræstelia.—The following description is written from the specimens which were obtained by cultivating the spores of undoubted *Gymnosporangium macropus* upon leaves of the common wild crab (*Pirus coronaria*). The first appearances of the *Ræstelia* is a thickened orange patch upon the infested leaf, soon bearing minute dark points upon the upper side (Plate XI, Fig. 1). These spermogonia are followed shortly by the acidia upon the under side, which are usually in a circle from a quarter to a third of an inch across. The wall of the cup when fully ripe is ashy white, delicate, and splits to the base into numerous slender threads which turn outward and downward (revolute) and touch the base of the peridium (Plate XII, Fig. 1). The cells composing the peridium are 13 to 16 by 100 to 110 μ , and much thickened with transverse striae upon the inner or concave side. The spores are brown, almost chocolate colored, smooth, somewhat polygonal, and 26 to 33 μ in diameter. In the cultures the stem is often infested with the fungus, and the branch is frequently distorted.

The ease with which the wild crab can be inoculated with the *G. macropus* is remarkable, and not the less striking has been the entire absence of the rust from all kinds of cultivated apple. In the midst of the otherwise full measure of doubt as to the *Ræstelia* of the apple there comes this result of close observation for the past three years. In view of this and other facts of a like nature it seems to me that

too much of the injury to orchards from rusts has been ascribed to *G. macropus*, which is a conspicuous wide-spread species, more easily detected by the general observer than any of the other species having *Ræstelia* growing upon the cultivated apple. The repeated failures of the sown sporidia to produce *Ræstelia* upon any variety of cultivated apples at Ames, Iowa, while at the same time and under similar conditions there has been no failure to obtain abundance of the rust upon the wild crab, furnish ground for this doubt in the prevailing belief. The relation between the two forms is so manifest that cedar and crab-apple trees which stand within ten rods of each other are both very badly infested and have been for years, while cultivated apple trees no farther distant from the same cedars have uniformly failed to develop the *Ræstelia*. There are no doubt great differences of susceptibility among cultivated sorts, and it is possible that in this vicinity only the varieties which are proof against the rust are to be found. However, the college nursery is not more than thirty rods from some infested cedars, and in such nursery rows a large assortment of apples, mostly Russian, however, are grown in great numbers. None of the *Cupressineæ* grow native near the college, and the *G. macropus*, as far as close inspection can determine, is the only species in the vicinity. In other portions of the country where the cultivated apples are badly infested it may be that the rust is due to one or more of the other species of *Gymnosporangium*. For example, the *R. lacerata*, which is a form of *G. clavariaforme* of the common juniper, is well understood as growing upon cultivated apple. Also *R. aurantiaca*, the form so conspicuous upon the quince fruit, is a pest in the apple orchard, and has as its teleutosporic condition the *G. clavipes* which infests both the red and the common cedar.

VI.—TREATMENT.

As a remedial measure it passes without further comment that it is well to destroy all specimens of the red cedar or savin (*Juniperus Virginiana*). In that way the only known host of *G. macropus* would be destroyed and one of the two for *G. clavipes*. The remaining hosts for *Gymnosporangia*, which, in their *Ræstelia* form, infest the apple are the white cedar (*Cupressus thyoides*) and common juniper (*Juniperus communis*). The range of these two species is very wide and the former often attains to a large size and produces a durable quality of timber of great service in many ways. The common juniper, growing, as it does, only as a low shrub, could be disposed of without seriously marring the beauty of the landscape or doing injury to any American industry. The red cedar is a prominent ornamental shrub or small tree, and there would be some objection to its eradication. If it must remain it would not tax the patience of a conscientious fruit-grower to go over the plants in late autumn and gather the "apples" before they have arrived at that state when they can be infectious to the apple trees. The galls are annual, not deeply seated, and can be quickly removed without doing violence to the tree. It would be better to do this gathering in late autumn or even in winter than to delay until spring, with all of its hurry caused by the pressing work incident to the opening season. The wild crabs or any stray trees of the cultivated sorts must not be overlooked, for they, and particularly the crab, furnish

a means of continual propagation of the pest, especially if the *Rosella* is perennial. It is fortunate for the orchardist that the uprooting of all such wild apples is no serious sacrifice, and for other reasons, as a rule, barring a single week of a profusion of fine sweet-scented blooms in spring, these plants may well be classified among perennial weeds of large growth. It is, perhaps, unnecessary to treat here of any remedies that may be applied similar to those that have proved efficient in checking the inroads of the mildews upon the grape, unless it be to spray the fruit trees at just the time when the sporidia are apt to come in contact with the foliage. No set time can be laid down for this, as it will depend upon the locality and season. Inoculation takes place shortly after a rain in middle spring and the period would be long or short depending upon the prevailing weather at the time. As the labor of making the required applications, to say nothing of the expense for apparatus and chemicals, would be much more than the gathering of the cedar apples in the case of *G. macropus*, it goes without further saying that remedial measures other than the knife are here neither urged nor recommended. It would be less easy to cut out the affected portion of the white cedar bearing *G. Ellisii* and of the common juniper with its *G. clavipes*, which would eradicate the quince rust as well, and *G. clavaria-forme*, but this is the shortest way. As for the latter host it may as well be pruned level with the ground, but for the white cedar the case is less easily met. However, it may be that *Gymnosporangium Ellisii* is one which is the least injurious of all.

Very likely some varieties of cultivated apples are more susceptible to the rust than others, but as the observations upon this point are meager and fragmentary it is not safe to draw any general conclusions from them. Varieties like Failawater and Red June are mentioned as subject to the rust, while the Early Harvest and Red Astrachan are not badly attacked. If it is true that *G. macropus* is the cause of the larger part of the rust of cultivated apples the experiments in Iowa would indicate that the varieties from Russia and elsewhere which are being tested for hardiness in the severe and treacherous climate of the State were proof against the rust caused by *G. macropus*.

In treating of the rust of the grain it was shown that there were three distinct stages through which the fungus passed from the telutospore to the final state again. In short, there was the acidio, the uredo, and the teluto conditions. In such a parasite it is evident that the difficulties of eradication are multiplied. In the apple rusts there are only two known forms, namely, the acidio and the teluto conditions. With the wheat rust one remedy consists in destroying the barberry; the rest of the work of eradication needs to be, from the nature of the fungus, largely preventive. To this end the seed wheat is soaked in chemicals, the leading one of which is cupric sulphate (sulphate of copper, blue vitrol, blue stone, etc.), for the purpose of destroying the adhering rust germs. All the rusts are deeply seated parasites which do not show themselves upon the surface until it is too late to apply an effective remedy. Therefore but little can be hoped for from direct action of remedies upon the affected parts. With our apple rust both the hosts are trees, and in most cases the fungi are perennial; it therefore follows that the preventive measures used in connection with seed grain do not apply.

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10.—SEPTOSPORIUM ON GRAPE LEAVES.*

(Plate XIII.)

I.—GENERAL OBSERVATIONS.

During the summer of 1887 Professors Scribner and Viala collected a fungus on the wild grape vines (*Vitis Californica*) at Orange, Cal., which in external appearance closely resembles *Septosporium Fuckelii*, known only on foreign vines.

The following is an extract from Professor Scribner's note-book:

“Found on leaves of wild vines, *Septosporium Fuckelii*. Leaves on some vines destroyed by this fungus. On the upper surface, the first appearance of the disease is comparable to that of the Downy Mildew. Spots on underside nearly black and round, not irregular, as with *Peronospora*.”†

The spots referred to grow larger and coalesce, so that occasionally nearly the entire leaf surface becomes black below and brown above. It has not been reported on the cultivated grape.

*SEPTOSPORIUM HETEROSPORUM. ELLIS & GALLOWAY.—On living leaves of *Vitis Californica*, near Orange, Cal. Collected by Prof. F. L. Scribner, October, 1887.

Spots scattered and more or less confluent, indefinitely limited, rusty brown above, one-half to 1 centimeter in diameter, smoky black below or appearing gray on account of the tomentum of the leaf.

Hyphæ hypophyllous, issuing in fascicles from the stomata of the leaf and bearing at their apices the very variable conidia which are at first oblong-cylindrical, 2 to 3 septate, 20 to 40 by 5 to 7 μ , like the conidia of a *Cercospora*. These conidia soon become constricted at the septa and each of the three or four cells become uniseptate. The three primary septa gradually become deeper until the conidia finally separate into three or four separate uniseptate segments of a short elliptical or nearly spherical shape, about 12 μ in diameter, with the epispore distinctly roughened. We have compared this with specimens of *Septosporium Fuckelii*, Thüm., as represented De Thümen's Mycotheca Universalis, 671, and with specimens collected in Algeria by Professor Viala. The California specimens differ in their much shorter hyphæ and very different conidia, which are much constricted at the septa.

†Botanical Gazette, January, 1888.

II.—BOTANICAL CHARACTERS.

The black appearance of the lower surface is caused by the fruiting portion of the fungus. The sporophores are in tufts which project from the stomata, and are borne upon a knot of mycelium just under the epidermis. They are composed of short, septate, dark colored hyphae, rounded at the apex and tapering toward the base, each bearing a chain of conidia.

The spores are dark colored, numerous, and usually several septate. At first they are smooth, not constricted at the septa, and generally not more than four celled, but as they grow older the surface becomes rough, the number of cells increase, they become much constricted at the septa, and occasionally longitudinal septa make their appearance (Fig. 4). New septa also appear in the older spores. The time of the formation of the septa may be inferred by their thickness and the degree of constriction around them. The different cells continually become more and more spherical, so that the older cells are nearly perfect spheres and have a tendency to fall apart. The chains of spores assume very different shapes according to their age and environment. The spores examined were from dried specimens and the phenomena of growth were not observed, but, judging from the forms assumed, the process of development would be as indicated. The appearance of roughness of the spore-walls, especially in immature specimens, *appears* to be due to a granular arrangement of the contents, but if these are shrunk by some reagent the irregularities do not disappear and are plainly seen to exist in the walls.

These fruiting tufts may be entirely independent, but they are also found in connection with a spermatogonial form (Figs. 5, 6). In this case they spring from the side or apex of the capsule, passing through a stoma as before. The spermatogonia may also be independent (Fig. 6), not connected with any conidial form, and having the ostiola situated beneath the stomata. In these independent capsules the cells around the ostiolum frequently project a little, giving the impression, when looking down upon them, that the conidiophores have broken off at the base; and this idea is strengthened by finding septa at the base of nearly every fruiting hypha. Frequently also the stroma at the base of the conidiophores is much enlarged, as if a spermatogonium were in process of formation.

The spermatogonium is a thin-walled, yellowish brown capsule, its outer cells frequently extending into mycelium threads. It is lined with a layer of colorless, flask-shaped cells, on which the spermatia are borne; these seem to be produced in chains, which fall apart, leaving the spores septate. The spermatia (Fig. 7) are bacillus-like and partake of the Brownian movement. They measure 4 to 7 by $1\frac{1}{2}$ to 2 μ , are usually straight, sometimes slightly curved, and usually larger at the ends than in the center.

The differences between this form and *Septosporium Fuckelii* may be seen by comparing Figs. 1 and 2 with 3 and 4. The conidiophores and spores of *Fuckelii* are more slender and the conidiophores are longer; those of the new form are clavate, but those of *Fuckelii* are not. It would be well to say in this connection that in Viala's *Les Maladies de la Vigne* the conidiophores of *Fuckelii* are drawn clavate. The drawing in this report was made from a camera-lucida sketch of material collected by Professor Viala in Algeria, and is true as regards this material. There is probably a considerable vari-

ation between different specimens. There is, however, much difference in the spores. The mature spores of *Fuckelii* are almost identical with the young spores of the American species, but the older spores of the latter are broader, constricted more or less deeply at the septa, and the surface shows peculiar markings, due to irregularities which are not present in *Fuckelii*. The illustrations of the spores show typical forms of both species, but the tufts of conidiophores both contain rather fewer than the average number of hyphæ.

Viala gives the length of the spores as from 30 to 60 μ . Those we have measured vary from 5 to 10 by 20 to 55 μ , and those of the American species measure 5 to 12 by 13 to 50 μ . The mere figures do not indicate much variation between the species. The specific differences consist rather in the shape and general appearance of the spores and conidiophores, and in the fact that one species is found in connection with spermogonia and the other is not.

11.—LEAF-SPOT DISEASE OF THE MAPLE.

Phyllosticta acericola, C. & E.

(Plates XIV, XV.)

I.—GENERAL OBSERVATIONS, HISTORY, ETC.

In many parts of the West, maple trees, especially those belonging to the silver-leaved species, *Acer dasycarpum*, are frequently attacked by a parasitic fungus which greatly injures their appearance and lessens their value.

The fungus attacks the leaves exclusively, destroying the chlorophyll (green coloring matter) wherever it gains a foothold, and consequently interfering with assimilation. This may occur to such an extent as to decrease the growth of the wood, causing the trees to become weak and more or less stunted. In addition, the foliage becomes very unsightly (Plate XIV), so that in sections where the disease is especially prevalent people prefer to plant shade trees not subject to the attacks of such disfiguring maladies, and in consequence the sale of maples by nurserymen is considerably diminished.

The disease is especially severe where a large number of trees are grown together, as in nurseries and groves. Isolated trees are rarely seriously attacked.

The beauty and grace of the maple and its easy cultivation have long made it one of the most popular and widely used of all our shade trees. A disease, therefore, which injures it in any way demands our attention.

Hosts.—The fungus attacks the species *dasycarpum*, *rubrum*, and *Pennsylvanicum*.* In the West *Acer dasycarpum* suffers especially from its attacks; but in the District of Columbia it is *A. rubrum* that seems to be most subject to the disease, and *A. dasycarpum* is comparatively exempt.

Geographical distribution.—So far as known the fungus is restricted to this continent, but it seems to be very wide-spread through the United States. It is reported from New York, New England, New Jersey, Illinois, Kansas, and other States. It has also been found

* As a matter of convenience the different species of maple will be referred to here under their botanical names, as follows: *Acer dasycarpum*, White or Silver maple; *Acer rubrum*, Red maple; *Acer Pennsylvanicum*, Striped maple.

abundantly in the vicinity of Washington, D. C. In the nurseries of Missouri Agricultural College it caused considerable injury to the young trees three or four years ago.

History.—The fungus causing the disease seems to have been first collected in New England on *Acer rubrum* by a Mr. Sprague, and described from his species in 1874 by Messrs. Berkeley and Curtis as *Sphaeropsis minima*.* In 1879 Peck reports finding it on the same host in Greenbush, N. Y.† In 1880 Cooke and Ellis described a fungus found on "Maple leaves" in New Jersey which they called *Phyllosticta acericola*.‡ In his *Sylloge Fungorum*, Saccardo publishes these species as independent, but changes *Sphaeropsis minima*, B. & C. to *Phoma minima*, Sacc.§ In the *Journal of Mycology* for 1886|| Dr. George Martin gives *Sphaeropsis minima* as a synonym of *Phyllosticta acericola*, and finally Farlow in his *Host Index*¶ has published *Phyllosticta acericola*, C. & E., *Sphaeropsis minima*, B. & C., and *Phoma minima*, Sacc., as synonyms.

If the law of priority is to hold in the nomenclature of fungi, this fungus probably ought to be known as *Phyllosticta minima*, (B. & C.), C. & E., but since it was published independently by Cooke & Ellis as *P. acericola* and this name afterward adopted by Dr. Martin it is the one that will be used in this paper.

II.—EXTERNAL CHARACTERS.

It makes its appearance upon the leaves about the middle of May, in the form of small, blackish, more or less circular spots, which rapidly increase in size. As they enlarge their shape becomes more and more irregular, their color meantime changing from black to different shades of brown. On *Acer dasycarpum* (Plate XIV) the color of the spot becomes almost a dirty white in the center, surrounded by a black-brown border. On *A. rubrum* the center is reddish brown and the border dark or purplish. The external appearance on the two species is so different as to give the impression to the casual observer of two different fungi. The texture of the spots is also different. In *A. dasycarpum* the diseased tissues are very much more brittle and less coherent than the healthy ones, often showing a disposition to break away from the green portions of the leaf. In *A. rubrum* the affected parts are much firmer, although still more brittle than the healthy portions of the leaf. They, however, do not have the thin, fragile appearance possessed by the spots on *A. dasycarpum*. The difference both in the color and texture of the spots on the two species can probably be accounted for by the difference in color and texture of the healthy leaves. *Acer rubrum* possesses a darker, firmer leaf, the tissues of which would break down much less easily than those of *A. dasycarpum*.

When the spots have attained their full size they vary from 10 to 14 millimeters in diameter, are irregular in outline, and often run together, forming a large irregular patch. In the worst cases the

* *Sphaeropsis minima*, B. & C.—Maculis pallide brunnéis; peritheciis minutis, tectis, sporis breviter obovatis. On leaves of *Acer rubrum*. New England, Sprague. No. 5314. Forming little sub-orbicular brownish spots: perithecia sub-cuticular, minute, spores shortly obovate, 4 μ long. Grevillea, Vol. III, p. 2.

† 30th Rep. N. Y. State Museum, pp. 31 and 77.

‡ Grevillea, Vol. VIII, p. 11.

§ Vol. III, p. 116.

|| Page 13.

¶ Part I, p. 19.

greater part of the leaf surface becomes occupied by these brown or grayish white patches, and the leaf finally shrivels and dies. The young leaves are attacked as soon as they appear, so that the falling off of the old ones does not free the plant from the attacks of the parasite.

III.—BOTANICAL CHARACTERS.

At any time during the summer or autumn, small black dots, scattered over the lighter portions of the diseased spot, may easily be seen with the naked eye (Plate XIV). Under the microscope these prove to be thin-walled, hollow bodies (Plate XV, Fig. 1), containing the spores or reproductive organs of the fungus. These conceptacles, otherwise known as the pycnidia, are somewhat flask-shaped, have dark-colored walls one or two cells thick, and are provided with an opening or ostium for the discharge of the spores. They are also lined with colorless tissue upon which the basidia or spore-bearing stalks are borne.

The thickness of the pycnidia walls and of the lining tissue varies in different hosts, the walls are more distinct, and the layer of colorless tissue thicker in *A. rubrum* than in *A. dasycarpum*.

The spores are colorless, granular bodies 8 to 9 μ long by 5 to 6 μ in diameter, and usually contain one or more rather large sized vacuoles. They are nearly oval and often somewhat angular in shape, this being caused by the pressure of the spores against each other before they escape from the conceptacle.

The spores are produced in the following manner: The colorless lining tissue gives rise to multitudes of small, cylindrical, club shaped bodies which stand at right angles to the wall of the pycnidium; the free ends of these swell up, and are finally cut off from the supporting portion by a septum. The upper portion has then become the spore and the lower part the basidium, or stalk; the latter is from 10 to 12 μ in length and about 4 μ in diameter, and usually tapers a little towards the spore. The spore finally breaks off from the stalk and passes out through the ostium. These mature spores are capable of reproducing the fungus. If kept for a time in a drop of water they will germinate by sending out a slender filament (Plate XV, Fig. 2), which soon develops into a mycelium. If, as occurs in nature, these spores fall on the leaves of the maple and are there wet by the rain or dew the same thing will happen, but in this case the germinating filament bores into the leaf and the mycelium developing within the leaf tissues feeds upon the plant juices which are required for the sustenance of the plant itself, and interferes with the assimilating power of the leaves.

The mycelium or vegetative part of the fungus is found exclusively between the cells. No haustoria could be determined, but in some cases the cells were so firmly united to the mycelium filaments that they could not be separated by repeated jarring under the cover-glass, even when the specimens had been so macerated that the cells of the host fell apart readily. In the specimens examined the mycelium in *Acer rubrum* (Plate XV, Fig. 3 a) was considerably coarser than in *Acer dasycarpum* (Plate XV, Fig. 3 b, c), but in other respects it is the same. It is branched, septate, and filled with granular protoplasm in both cases. As has been stated, this is the first portion of the fungus to develop between the cells of the host, but it soon forms condensed masses here and there just beneath the upper surface of the leaf. These increase in size and finally rupture the

epidermis, producing the black dots or pycnidia already described. The process of differentiation of the pycnidium and its contents has never been completely followed out.

During winter the fungus lives in the tissue of the decaying leaves, and the stylospores retain the power of germination until the new leaves have come out the following spring. Last spring (1888) stylospores were found in abundance, and germinated as late as the middle of April.

Some leaves that had been left on the ground over winter were examined the following summer, and some of the conceptacles on the diseased spots were found to contain what seemed to be immature asci. These conceptacles or perithecia closely resemble the pycnidia in all respects, save as to their contents, and in the specimens examined these were somewhat indistinct, but the main part of the cavity was plainly filled with bodies closely resembling asci in their shape and arrangement, although no spores could be distinguished. This fact merely increases the probability that the form of the fungus with which we are familiar is only one stage in the life history of an ascosporous species.

IV.—TREATMENT.

No line of treatment has ever been attempted for this disease, and any suggestions in the matter must be purely theoretical, based, however, on a knowledge of the habits of the fungus and the properties of fungicides already tested in similar cases.

Since the fungus lives over winter in the leaves it is obvious that a source of infection will be removed if these are collected in the autumn and burned or buried before they are scattered by the wind. In nurseries where the trees are small it is probable that good results will follow the application of some fungicide which, interposing between the surface of the young leaves and the spores which may fall upon them, will prevent the germination of the latter or destroy their germ-tubes.

Doubtless a solution made by dissolving half an ounce of sulphuret of potassium to the gallon of water will be found as cheap and efficient as any for the application. The solution should be applied to the foliage by means of a force-pump having a nozzle of fine aperture, such as the Riley "Cyclone" or Nixon "Climax," which will distribute the liquid in a fine spray. The first application should be made about the time the leaves are two-thirds grown, repeating the operation every three or four weeks if the season is wet. In nurseries it would be well to select new sites for plantations of young trees as often as possible, as observation has shown that maple trees grown for a number of years in succession upon the same spot suffer more than those in new soil.

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 <i>Ibid.</i>, p. 116: <i>Phoma minima</i>.</p> |
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12.—A DISEASE OF THE SYCAMORE.

Glæosporium nervisequum, Sacc.

(Plate XV.)

I.—GENERAL OBSERVATIONS.

For several years the Sycamore trees in the vicinity of Washington have suffered during the spring from the attacks of a parasitic fungus which has been so severe that in many cases the whole tree appeared as if scorched, and sometimes died. The effects of the disease are so conspicuous, and have attracted so much attention, that many will probably be glad to learn the cause of the trouble and history of the disease, even if there is no approved method of removing it.

In 1888 it appeared about the middle of May, and by the last of June many of the largest trees were entirely defoliated. On May 30 the trees along the Virginia side of the Potomac for a considerable distance down the river were carefully examined and every tree, large and small, was found to be badly diseased. On the smaller trees the leaves were all affected alike, but on the large ones only the branches over the lower half showed any signs of the malady. Trees thus affected presented a very peculiar appearance: in fact we have often seen trees, under which large brush-heaps had been burned, having their foliage in exactly the same condition, *i. e.*, the lower half brown and withered, the upper half fresh and green.

Trees in the city were also affected, but not so seriously as those in the country. A row of Sycamores along the Boundary, between Tenth and Twentieth streets northwest, were quite badly diseased. Here the malady was confined almost entirely to the lower branches, although the trees were comparatively small, many of them being less than 25 feet high.

Trees near Hyattsville and College Station, Md., were in a number of instances killed outright by the disease, but most of those in or near the city recovered toward the middle of summer, at which time the malady had for the most part disappeared.

Geographical distribution—It has been observed in Ohio, Kentucky, and Indiana, and we have reliable evidence that it existed in New Jersey (Ellis) and Illinois (Waite). It has been collected in California by Harkness on *Platanus orientalis*,* and Dr. Vasey states that a number of years ago his attention was called to what was probably the same thing while traveling through Kentucky. So far as known the disease does not occur in Missouri, and careful observations during the past season in Mississippi failed to reveal its presence there (Tracy). It is present in Europe, where it has been found in Germany, Italy, and France.

Hosts.—It occurs on *Platanus racemosa*, *orientalis*, and *occidentalis*, and Fuckel reports it upon *Quercus*. Hitherto it has been reported on the leaves only, but we have found it on the growing, unglorified stems and on the petioles.

History.—It was first named *Hymenula plantani* by Leveille, and the description was published in the *Annales des Sci. Nat.* for 1848.†

* Journal of Mycology, Vol. I, p. 110.

† *Hymenula Plantani* nov. sp. Receptaculis gregariis ampligenis innatis dein erumpentibus minutis carnosulis, orbicularibus vel ovatis pulvinatis, flavo-rubrescentibus macula exarida insidentibus; sporis ovatis, vel curvatis continuis utrinque obtusis.

Hab. in Gallia meridionali. Legit cl. Castagne ad folia *Plantani orientalis*.

Fuckel changed it to *Fusarium verticillium*, but Saccardo has transferred it to the genus *Glaeosporium*, and this has been adopted by Ellis in the Journal of Mycology.

II.—BOTANICAL CHARACTERS.*

The effects of the fungus are most evident on the young leaves at the ends of the branches. The leaves seem most liable to attack at about the time they have attained their full growth. When the disease attacks the leaves themselves a brown patch of variable size makes its appearance, either where the veins fork at the base of the leaf, or somewhere along the course of the nerves. When a vein is attacked the flow of sap is checked, and the parts of the leaf that are supplied with sap by the vein in question will wither and die. Sometimes, however, there is a small diseased spot along a vein with no other perceptible effect of the fungus. The spots are dry and brittle, and a close examination will reveal small, dark dots on both surfaces, especially along the veins on the lower side.

Very often, however, a leaf or all the leaves on the end of a growing branch suddenly wilt, and the closest examination will not show any traces of the fungus. In this case it can invariably be found on the petiole or on the branch itself, where its action in breaking down the tissues has cut off the supply of sap from the leaf or leaves beyond.

The dark colored dots already referred to are small pustules containing the fruit of the fungus. On the leaf (Plate XV, Fig. 5) this usually forms just beneath the lower epidermis. Within the pustules and resting on the outer cells of the mesophyll is a thin hymenium, formed of colorless, thin-walled pseudo-parenchyma. This bears a layer of straight, cylindrical, pointed, colorless basidia set close together, which are septate at the base and bear spores on their free ends. The spores (Fig. 6) are one-celled, ovate, and colorless. The pressure of the basidia and spores ruptures the epidermis, after which it usually turns back entirely, exposing the layer of basidia and spores.

On the living bark of the preceding year there are often small protuberances resembling lenticels, but more elevated; sections through these reveal two conditions of a fungus. In the *Botanisch-Zeitung* for 1886 Franz von Tavel has published a very full description of this fungus under the name of *Discella platani*. In the earlier stages it is merely a cone-shaped mass of pseudo-parenchyma, apparently formed by the lateral union of parallel filaments. After a time basidia and spores are formed in the center of the mass, and finally the entire cone disappears, leaving an ordinary fruit pustule, strikingly resembling those of the *Glaeosporium* on the leaf, except that it is larger and the stroma at the base of the basidia thicker (Fig. 4). There is an abundant colorless, septate, branching mycelium which completely breaks down the tissue. Von Tavel made repeated cultures of the spores of this fungus with a view to ascertaining whether it had any genetic connection with the *Glaeosporium* on the leaves, but the results were negative. The first impression upon seeing the mature form of the *Discella* is very strong that it is the

*The microscopic work represented in this paper was completed with one exception, before Von Tavel's paper came to the knowledge of the author: the one exception is in regard to the intermediate stages between the mature and immature form of *Discella platani*.

same thing found on the leaf, but beyond the morphological evidence there is no proof, save that diseased stems and leaves do often come from the branches upon which we find the *Discella*. It is possible that the fungus may have two forms of development, one for the leaf and another for the bark, and that the formation of the pseudo-parenchymatous mass at first is necessary in order to rupture the cork layer and the epidermis of the bark and allow the escape of the spores. Von Tavel considers this as the pycnidium form of some fungus.

In spring many of the younger branches on the diseased trees are dead and spotted with small, dark colored pustules. These pustules are made up of several capsules containing spermatia like spores. They disappear by the latter part of June, leaving an empty, dark-colored cavity in the bark.

Whether or not this is what Von Tavel calls *Cytispora platani* we have no means of deciding. The perithecia form was not found, and we have no specimens for comparison.

In addition to these forms there is another, which sometimes occurs upon the ends and buds of dead branches. It consists of very large, irregular pycnidia, containing large spores borne upon prominent basidia. The spores are colorless and one-celled when young, and dark yellow and often two-celled when mature. This can hardly be Tavel's *Fenestella platani*.

Whether or not there is any genetic connection between these forms and the *Glaosporium* is an open question. Von Tavel's carefully conducted experiments are without definite result save in the line of the *Cytispora*, and in this case the evidence goes to prove that it is quite independent of the *Glaosporium*, having, on the contrary, an *Acrostolagmus* as its conidial form.

It hardly seems reasonable that the life history of the *Glaosporium* is confined to the form on the leaves, especially when we consider that this stage only lasts about two months of the year. From the abundance of other fungi on the branches at the time when the *Glaosporium* makes its appearance it seems quite probable that one or more of them may be found to have some genetic connection with it.

III.—TREATMENT.

The size of the trees makes the use of fungicides very difficult; and the fact that the trees are not important from an economic point of view renders any attempt in this direction undesirable. It is always best to destroy any leaves that fall from the effects of the fungus, as in this way multitudes of spores are destroyed. In case of shade trees it will not be a very difficult task to remove all dead branches before the leaves come out in the spring, in order to avoid the possibility of the fungus originating from spores that might be produced on them.

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13.—THE LEAF RUST OF COTTONWOODS.

Melampsora populina Lév.

(Plate XVI.)

I.—GENERAL OBSERVATIONS.

The leaves of poplars, especially the Cottonwood (*Populus montifera*), are frequently covered during summer and autumn with an orange rust. The affected trees shed most of their leaves during summer long before the regular time, and frequently attract attention by their defoliated appearance.

This rust is not very conspicuous and might easily pass unobserved, but upon taking one of the fallen leaves in hand it is seen to be covered with small yellow pustules from which at maturity a fine yellow powder is discharged over the surface of the leaf. Later, during autumn, the leaves become covered with small, reddish-brown specks, not powdery in their nature, but hard and crust-like, scarcely raised above the surface.

The yellow powder and dark-colored specks are masses of spores or reproductive bodies of a parasitic fungus, a minute plant belonging to the family *Uredineæ*, or rusts.

The most remarkable fact concerning the *Uredineæ* is the polymorphism or alternation of forms which most of the species undergo. As a rule they pass through three different stages, producing each time a different kind of spore. These conditions are quite unlike, and older botanists thought they belonged to different genera. In the spring the cluster-cup condition develops. In this stage the spores, usually light yellow in color, are produced in little cups which burst through the epidermis of the leaf forming what is known as the *acidio* stage. During the summer the second stage or *uredo* form appears usually on a different host plant from the first. Its spores are commonly thin walled, covered with minute spines, and borne on very fragile stalks.

The mature reproductive bodies called the teleutospores develop at the close of the season, usually on the same host plant as the *uredo*-spores, and frequently on the same spots. The teleutospores are thick walled, dark colored, and filled with dense protoplasm. While the *uredo*spores must germinate soon after maturity or else not at all, the teleutospores usually refuse to grow until the next season. The former are for the purpose of rapidly spreading the fungus during the growing season; the latter are capable of surviving the winter and serve the purpose of the seeds of higher plants.

II.—EFFECT ON HOST.

The mycelial threads of the fungus penetrate but a short distance laterally. Indeed, only a few cells each way from the small yellow sorus are reached by the parasite. A minute yellow spot extending through the leaf and visible on the opposite side surrounds each of the *uredo* sori. This is the only direct effect of the *uredo* form on the leaf tissue. The formation of the teleutospores draws more heavily on the vitality of the leaf, and when their sori occur thickly the leaf tissue is killed and the green coloring matter decomposed so that an irregular brown patch is formed or frequently the whole leaf discolored.

The most important effect which this fungus has on its host is that of causing the leaves to fall prematurely. The shedding of leaves by trees is a natural process; they are cut off by the formation of a plane of cork cells through the place of separation. Some trees are peculiarly sensitive and drop their leaves at the slightest disturbance, as, for instance, improper nutrition. The Cottonwood is one of this sort, and the disturbance which the fungus creates in the leaves is sufficient to cause them to fall. We have observed a row of Cottonwoods planted for shade almost completely defoliated from this cause by the middle of August.

III.—HOSTS AND GEOGRAPHICAL DISTRIBUTION.

Melampsora populina is common in the eastern and central portions of the United States on the Cottonwood (*Populus monilifera*), and occurs occasionally on the American Aspen (*P. tremuloides*), the angled Cottonwood (*P. angulata*), the large-toothed Aspen (*P. grandidentata*), the Balsam Poplar (*P. balsamifera*), and the Balm of Gilead (*P. balsamifera* var. *candicans*). It has not yet been reported from the far West or the Pacific coast, but will probably be found when looked for.

In the Old World it grows on *Populus nigra* and several other species of Poplar, and is found in all the countries of Europe and in Asiatic Siberia. It probably occurs entirely around the world in the North Temperate Zone.

IV.—BOTANICAL CHARACTERS

If a small quantity of the orange-colored dust from one of the uredo sori be transferred to a slide and examined under a high power of the microscope it is found to consist of minute rounded or obovate, light-colored, thin-walled bodies which are covered with minute tubercles. These are the uredospores (Fig. 3); and in thin sections it is seen that they originate from a mass of mycelium beneath the epidermis. As the growth of the parasite proceeds, the latter is forced upward, finally ruptured (Fig. 1), and remains for some time as a partial covering for the sorus. Among the uredospores in the pustule are borne club-shaped paraphyses (Fig. 3 c). Both spores and paraphyses arise from a layer of fungous tissue, the *hymenium*.

The uredospores are apparently sessile; in fact, Burrill,* in defining the genus, says, "uredospores sessile upon the hymenium." Winter,† however, says that they are borne on basidia. The fact is they are provided with pedicels which so closely resemble the cells of the hymenium that they may easily be taken for the latter. Moreover, they project slightly, if at all, above the general level of the hymenium and separate very easily from their attachment when mature. By careful manipulation, however, the spores may be isolated with the pedicels attached; it is then seen that they differ from the ordinary pedicellate uredo forms only in the length of their stalks (Fig. 3).

Turning to the mature form of the fungus, a section through one of the crust-like, dark-colored teleuto sori (Fig. 2) shows an altogether different appearance. The teleutospores (Fig. 4) are not un-

* Parasitic Fungi of Ill., p. 211.

† Die Pilze, p. 237.

like the palisade cells of the leaf in size and shape, but are distinguished from them by their brownish tint and granular protoplasmic contents. They are oblong-cylindrical in shape with a smooth, thin wall. They are closely packed into a single layer with the longer diameter at right angles to the stratum, in the manner of paving-blocks, and grow more or less prismatic in shape from mutual pressure. They are inclined to be slightly wedge-shaped, with the larger end up, and are more slender, longer, and regular in the large sori than in the small ones. A stratum of these spores develops in small spots beneath the epidermis, and in a section cells of the latter may be seen much flattened and distorted (Fig. 2). In a few cases small, crowded masses of teleutospores were found farther inside the leaf-tissue, not forming a crust under the epidermis. These spores are more nearly round than the others. The teleutospores are not borne on stalks, as is commonly the case among the rusts, but arise directly from a cushion of cellular fungous tissue (Fig. 2).

The mycelium is very meager, consisting of mere prolongations of the hymenium among the adjacent host cells: in no case were slender mycelial threads of any considerable length seen. The mycelial branches are always short, septate, and irregular. In a few cases the host cells lying close under the center of the sorus were so broken down that they seemed to be penetrated by the mycelium; but even here it was not satisfactorily made out on account of the difficulty of distinguishing between the discolored protoplasm which clung to the sides of the cells and the fungus mycelium. However, the common occurrence of the mycelium was between the cells, which seemed to be little distorted by its action and not seriously disturbed in function. In most instances the host cells under the uredo sori retain their green chlorophyll, even though the cell may be completely surrounded by the parasite.

V.—TREATMENT.

From the nature of the trees attacked, usually large, it would be difficult to apply any remedy. Moreover, the parasites of the group to which this belongs are among those least affected by fungicides. The fungus grows wholly inside the host plant, and does not break through the epidermis so as to be easily seen until it is in full fruit.

From the usually small value attached to Cottonwoods, it would not be considered profitable to spray them, even though success were certain. By thoroughly raking up the leaves and burning them in the fall millions of the spores would be destroyed. The more thoroughly this is done the less will be the chances for infection the next year. This is probably the only attention which this disease can be expected to receive.

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14.—REPORT ON PEACH YELLOWS.

By ERWIN F. SMITH, Special Agent.

I.—TREES AFFECTED.

Yellows is primarily a disease of peaches and nectarines, but it has also been observed in almonds and apricots.

II.—WHEN AND WHERE DISCOVERED.

It was first written upon in 1806, having been observed in the immediate vicinity of Philadelphia prior to that date, perhaps as early as 1791, or even 1790. The peach itself has been successfully cultivated in this country since about 1630. It was first planted in the Chesapeake region, and not long after on the shores of the Delaware.

III.—FORMER SEVERITY.

Within a few years after it was first described, yellows appeared in all the Atlantic Coast States north of Virginia, and caused great loss, destroying in a few decades hundreds of orchards and thousands of trees in Delaware, New Jersey, Pennsylvania, New York, and Connecticut, and putting an entire stop to peach-growing in many sections.

IV.—PRESENT DISTRIBUTION.

In recent years this disease has appeared in Ontario, Michigan, Illinois, and Georgia, and seems not to have completely disappeared from any of its former strongholds. So far as known, yellows now extends from Maine to Georgia, and westward to Lake Michigan and the Mississippi River. It has not been reported from California or from any State west of the Mississippi, and its existence has not been definitely established in any of the Gulf States, although it undoubtedly occurs in some of them. This disease is also unknown abroad, or at least has not been described from any other part of the world. It should be looked for in the Mediterranean region, in China, in New Zealand, in Argentine Confederation, and especially on our own West coast, in California.

V.—PRESENT SEVERITY.

In recent years the disease has been no less destructive than formerly. Thousands of young and thrifty trees have been destroyed by it, and peach-growing has been abandoned in several parts of the country where formerly there were many large and profitable orchards, *e. g.*, at Saint Joseph, in Berrien County, Mich.; at Middletown, in New Castle County, Del.; near Niagara River in New York and Ontario; and along the bay shore in Harford County, Md.

The disease now prevails disastrously on the Chesapeake and Delaware Peninsula, in the most productive peach region on the continent. On this peninsula it is confined principally to the counties of Cecil and Kent in Maryland, and of New Castle and Kent in Delaware, but is extending into other regions formerly free. The disease is also now prevalent in Cumberland, Morris, and Hunterdon Counties in New Jersey, and in other parts of the United States. It is everywhere the same obscure, destructive malady.

VI.—SYMPTOMS.

The earliest unmistakable symptom of yellows is the premature ripening of the fruit. Diseased trees ripen their fruit, in whole or in part, from a few days to several weeks in advance of the proper time. Often the peaches on one or two limbs only will be diseased, all the rest ripening in a normal manner. In such cases the premature peaches are full-grown, ripe, and high-colored, when those on the rest of the tree are green and but half grown.

These peaches, no matter what their natural color, are more or less red and purple-spotted on the skin and splashed and streaked within. Sometimes the normally white or yellow flesh is very beautifully mottled, or almost entirely crimson; again, there is only a trace of abnormal color. The flavor of premature peaches varies considerably, but they are usually insipid and sometimes bitter. They are not fit to eat but are sometimes put upon the market in large quantities, especially early in the season and in years of scarcity. Such fruit can readily be distinguished from healthy by its high color and spotted appearance and should be rejected.

The next symptom, which generally appears the same season but is sometimes delayed until the next, is the appearance of diseased, dwarfed growths upon the trunk or limbs. These growths bear diminutive leaves, which are pale green, yellowish, reddish, or white, as if etiolated. They often show a marked tendency to repeated branching, sometimes as many as four sets of branches being developed in a few months. These growths may arise either from obscure buds on the trunk and main limbs or from ordinary winter buds. They may appear at any time during the season from spring until late autumn. Often the winter buds push in October or November, after the foliage has fallen, or even in August and September, while it is still green and vigorous.

When attacked the tree is very often in a vigorous, healthy looking condition, and sometimes during the whole of the first season there is no sign of disease beyond the appearance of a few premature peaches, the foliage being full-grown and dark green and the shoots in no way dwarfed or sickly. As already intimated, the disease usually appears first in one limb or on one side of the tree, but sometimes in all parts of the tree at once or on opposite sides. No matter to how slight an extent the tree is first diseased, it never recovers, but becomes entirely diseased in course of two seasons, or, at most, three.

The limbs first attacked are badly diseased the second year, their entire growth, shoots, and foliage, being much dwarfed and of a sickly green, tinged with yellow or reddish brown. In course of two or three seasons the entire growth of the tree assumes this appearance, and is then a sufficient warrant for the common name, such trees, especially when massed in orchards, being distinguishable at some distance by their yellow or reddish-brown appearance, which is in marked contrast with the beautiful dark green of healthy foliage.

Trees not infrequently die outright the second year of attack but ordinarily they languish for a number of years, dying gradually from the extremities downward. Often such trees are barren after the first year, or they may bear another crop of premature peaches, which are, however, of small size and very inferior flavor.

VII.—DISEASES MISTAKEN FOR YELLOWS.

Other diseases of the peach have been mistaken for this.

Trees may bear premature fruit when severely injured by the peach-tree borer, *Egeria crinitosa*, Say. The cause of this premature fruiting is easily discoverable. It never occurs until the tree is nearly girdled at the earth surface, and ready to die. The foliage of such trees is always yellowish, *i. e.*, when fruit is premature by borers it is never borne on healthy, vigorous-looking trees. Moreover, the peaches are not red-spotted, and the trees do not put forth the diseased shoots which are symptomatic of "yellows."

Root aphides (*Aphis chrysanthema*, Koch. ?) cause peach trees to assume a sickly yellow appearance. Often they are also much dwarfed, and not infrequently they die; but never, so far as I have observed, do they bear premature peaches or the characteristic shoots. On the roots of such trees, even in late autumn or winter, this aphid may often be found in large numbers. I have also seen it upon the branches in August and in January, but have never found the winged form.

The "root-knot," due to a parasitic worm, *Anguillula* sp., has made its appearance in Georgia, Alabama, and Florida, and causes the foliage of peach trees to turn a sickly yellow. If the attack is severe the younger branches die back, and sometimes the whole tree perishes, but without any symptoms characteristic of "yellows."

A soil deficient in food elements, *e. g.*, a barren sand, may also cause a yellow and stunted appearance, with premature aging and decay, but such trees plainly indicate starvation, and are in marked contrast to those attacked by yellows.

VIII.—CAUSE OF YELLOWS.

The cause of this disease is still unknown, but there is reason to believe it will be discovered at no distant day.

It has been attributed to severe freezing in winter, but this can hardly be a sufficient cause, because it occurs where the winters are not severe, and is absent in places where peach trees have suffered severely from the cold.

It has been attributed to excessive rain-fall, but it has been absent from one locality and present in another, when both suffered from excessive precipitation. Moreover, in localities wet in 1887 and dry in 1888 the disease seemed to prevail without reference to the changed condition, *i. e.*, as many healthy trees were attacked in 1888 as in 1887.

It has been attributed to impoverishment of the soil, especially to a deficiency of lime, potash, and phosphoric acid; but it now occurs on fertile soil, both virgin and highly improved, in as destructive a form as was ever observed in the most impoverished district, and is now absent from certain poor, sandy regions, deficient in the elements necessary to the growth of vegetation.

Yellows has also been attributed to parasites. I am inclined to think no insect has to do with the disease unless it be the root aphid before mentioned, and there seems to be enough evidence to rule this out. None of the higher fungi sometimes found in the parts above ground appear to stand in any causal relation to yellows. An unusual number of rootlets are dead in trees affected by this disease, and an evanescent cobweb mycelium observed on these rootlets

may be the cause, but is quite as likely to be a consequence, *i. e.*, a pure saprophyte. This possible cause and the root aphid are still under consideration.

Peach-growers have believed very generally that one great danger lay in the careless selection of pits for nursery stock, whereby many from premature peaches were included. The results of my attempt to grow infected trees from diseased pits were all negative. In 1887 over 3,100 pits from premature, red-spotted peaches were collected and carefully planted, but only fifteen trees resulted, all of which are now healthy. The peaches were taken from young and old trees, all vigorous and in the first stage of the disease, but in very many cases the pit contained no kernel or only an imperfect one—dry, watery, or black. Past experiments corroborate my own and indicate that the pits of very few premature peaches will grow.

Upon the theory that yellows is due to some "germ" which enters through the blossoms, it would seem as if one ought to be able to cut out the disease before it spreads through the entire tree. This theory is as old as the time of William Prince, and has been popular from the fact that the disease sometimes appears the first season in a single peach or in the peaches of one twig only, the rest of the tree appearing to be perfectly healthy. In 1887 and again in 1888, an attempt was made to remove the disease from slightly affected trees by prompt and severe excisions. From one-third to two-thirds of each tree was removed for the sake of getting rid of a few infected limbs. In most cases a large part of that which was removed and all of that which remained was perfectly healthy, of normal and vigorous fruit, foliage, and shoots be any indication of health. The results of the experiments in 1887 were entirely concordant and satisfactory. Twenty-four trees were under observation and in no case was the disease removed or its progress checked by the excisions. The possibility of re-infection was not excluded, but the probability is slight from the fact that in 1888 only 10 per cent. of the remaining healthy trees had become diseased, while every one, *i. e.*, 100 per cent., of the excised trees showed the disease. If these twenty-four trees were all re-infected it would seem that a larger number of the surrounding trees should have become diseased. Moreover, these twenty-four trees were all so badly diseased as to seem to preclude the idea of re-infection. They were nearly as bad as any of the other trees attacked in 1887. The result of the excisions made in 1888 is not yet known.

The result of some inoculations made in 1887 is also gratifying, and seems to put the communicable nature of "yellows" beyond reasonable doubt.

In August about one thousand healthy seedling trees were inoculate with buds from diseased trees as in ordinary budding. Owing to the interruption of this investigation in the spring of 1888, several lots of these trees were shipped without proper care and suffered much in transit so as to somewhat confuse results; but two lots, each of about two hundred trees, were uninjured, and to these the present discussion will be confined.

One of these lots, inoculated with buds apparently healthy but taken from a tree on which were some limbs in the first stage of the disease, was sent to a locality free from yellows, and up to the last of June showed no trace of the disease. Unfortunately these trees were not examined in the autumn, and their present condition is not known.

The other lot, inoculated with buds from the characteristic shoots of trees in the first year of the disease, was left in the nursery where budded. The result of these inoculations is very conclusive. The trees were examined in August, 1888, and again in November. Most of the inserted buds "caught," but very few of them grew. Some grew into shoots which seem to be healthy; others grew into diseased shoots, as was to be expected. The point of most interest is that about 40 per cent. of the previously healthy stocks contracted the disease from the inserted buds and sent out feeble wiry growths, often at a distance of some inches from the inserted buds. The evidence of this infection of the stocks could be seen in July, was clear in August, and still plainer in November, when nearly all of the winter buds on some of the stock shoots were just pushing under the influence of the disease. Even as early as August, 26 per cent. of the infected stocks were dead; and others, then languishing, were dead in November.

Of the entire lot of two hundred trees only thirty-nine appeared to be entirely healthy in November. The following table shows the condition of these trees in the autumn of 1888:

Result of experiment undertaken to determine whether yellows can be transmitted by budding. Trees inoculated in Maryland August 12, 1887. Buds selected from diseased shoots on young and thrifty trees of Crawford's Late.

Condition.	August examination.		November examination.	
	Trees.	Percent.	Trees.	Percent.
Healthy.....	47	23	39	19
Doubtful.....	21	11	24	12
Diseased.....	51	40	67	33
Dead.....	53	26	72	36
Total.....	202	100	202	100

From this table it is apparent that the condition of the trees was considerably worse in November than in August. It will be observed also that even in August a relatively large per cent. were dead. Earlier in the season many of these same trees put out feeble shoots from the inserted bud or the stock, but these grew only from one-half an inch to 3 inches and then died. A June examination would undoubtedly have shown a much larger number of healthy trees and fewer dead ones. The trees marked *Healthy*, as well as a majority of those marked *Doubtful* and *Diseased*, showed a green, thrifty-looking top, and at a distance gave no indication of disease. As a rule, however, their growth was not as robust as that of trees in the adjoining rows.

For comparison, trees were examined in the same row and in the row on each side to the number of five hundred and fifty and found healthy. These trees are of the same age and stock, and were budded at the same time, but from healthy trees. The contrast was very striking, and the comparison *left no doubt whatever* that in this case the disease was due entirely to the insertion of the unhealthy buds.

These trees are still under observation, and it is to be hoped that the other lot can also be examined and reported on during the coming season.

Additional experiments and laboratory investigations are under way and will be reported upon later.

IX.—REMEDIES.

All advertised "cures" are humbugs. No remedy is yet known. Nothing can be recommended with confidence, but it is very generally believed, especially in Michigan and Ontario, that the disease may be held in check by the prompt removal and burning of all diseased trees. To be effective this must be done promptly and completely upon the first appearance of the disease.

As an additional precaution it would be best to procure trees from localities not now suffering from yellows.

X.—ON REPLANTING, ETC.

The question is often asked, Will it pay to replant when orchards have been destroyed by yellows? That depends upon the nearness to market, the extent to which the disease is present, etc. In Michigan, where diseased peach trees are usually dug out promptly, peach orchards are on the increase, and the loss of trees per annum, it is said, rarely exceeds 5 per cent., and is usually much less. Even in New Jersey, where no restrictive measures are in force, and where growers expect to lose their trees after two or three crops, the business is still considered profitable, and many trees are planted each year to take the place of those diseased. Many growers hesitate to set trees in the place of those removed on account of yellows, but the results of trials in Michigan during the last ten years show that it can be done without danger. Trees thus reset are in no special danger. They do not contract yellows sooner than others in the same orchard. Peach-growing is so profitable, especially on the Chesapeake and Delaware peninsula, that this experiment is certainly worth trying upon an extended scale.

For an explanation of the text, see accompanying maps and illustrations, and for additional information consult a special report on Peach Yellows, recently published by this Section.

15.—ADDITIONAL NOTES ON CELERY-LEAF BLIGHT.

Cercospora apii, Fries.

In the Annual Report for 1886 this fungus was figured and described, and a partial account of the injury occasioned by it was furnished. More extended observations on the subject have shown that the damage to celery plants resulting from its attacks is greater than was at first supposed, owing to the fact that the peculiar yellowish appearance of the foliage which characterizes the disease is often attributed to "sun scald," "red spider," etc.

Our first experience with this malady was in 1881, at which time it made its appearance about the last of July in a number of beds, containing in all about 10,000 plants. The plants were grown from seed sown in a green-house in March, and were for the most part of the varieties known as "Boston Market" and "Golden Heart." The last of April they were pricked out in the open ground, and by the middle of June, being strong and vigorous, they were lifted for the last time and transplanted into rich, highly manured soil. They made a good start and grew rapidly for a few weeks, but about the last of July the plants in one bed began to show signs of disease and three weeks later nearly all the plants were entirely destroyed.

For a time endeavors were made to check the disease by destroying the yellow leaves as fast as they appeared, and by the application of solutions of hyposulphite of soda, sulphuret of potassium, etc. Despite all our efforts, however, the disease progressed rapidly, and the plants were finally abandoned to the fungus and weeds. The latter grew luxuriantly in the beds where the soil was unusually moist, and here the celery plants, which were well shaded, soon recovered from the effects of the fungus and remained healthy throughout the summer.

The next season the celery beds were made beneath several large locust trees which effectually protected the plants from the sun, and during the whole season not a plant thus protected was destroyed by blight. Our only explanation of the foregoing facts is, that celery being a native of a cool, moist climate it has not the constitutional vigor to withstand the hot, parching sun of our summers, consequently when exposed to the latter certain conditions which favor the development of the fungus and retard the growth of the celery are brought about, and as a result the latter succumbs to the attacks of the parasite. So far as our observations have extended the disease occasions the greatest injury in sections where the summers are long, hot, and dry. In regions where the soil throughout the hot months is cool and moist, and the air is also in a constantly humid condition, the disease is unknown. Just such conditions as the foregoing are to be met with in the vicinity of Kalamazoo, Mich., where the finest celery in the country is grown.

Where it is not practicable to shade plants by natural means, such as has already been referred to, artificial shades in the shape of screens made of coarse sacking or laths will be found fully as effectual. For several reasons lath screens are preferable to those made of cloth; they are cheap and easily made by nailing the laths at each end to two narrow boards 10 feet in length. The laths are usually placed about 1 inch apart, thus allowing plenty of air to reach the plants, at the same time effectually shading them. Such screens when finished are 4 feet wide and 10 feet in length; they may be supported by posts driven down on either side of the bed, the height of the former of course depending upon the size of the plants. As the plants increase in size the screens may easily be raised. At the approach of cool weather, which usually comes on in September, the screens may be discarded entirely, as the fungus at this season loses its activity. It remains alive, however, in the old leaves during the winter and following spring, but so far as we have been able to discover it does not change its form. Conidia were found on fragments of old leaves late in the spring of 1888, and these germinated readily when sown in water. A knowledge of this fact shows the importance of destroying the old diseased leaves in the autumn, as each small fragment of the latter harbors thousands of the reproductive bodies of the fungus. What is probably only a form of the parasite under consideration often attacks the common parsnip, a plant closely related to the celery, producing a diseased condition of the foliage similar to the celery-leaf blight. The fungus in this case differs slightly from that which occurs upon celery, but whether the two forms are really identical has not, so far as we know, been proved.

B. T. GALLOWAY.

Chief of Section.

Hon. NORMAN J. COLMAN,
Commissioner.

EXPLANATION OF PLATES.

PLATE I.

POTATO ROT—PHYTOPHTHORA INFESTANS, DBY.

- FIG. 1. Potato leaf, showing brown spots caused by the fungus.
 FIG. 2. Section through a diseased potato, showing discoloration in the outer portions, due to the presence of the *Phytophthora* in the tissues.

PLATE II.

POTATO ROT—PHYTOPHTHORA INFESTANS, DBY.

- FIG. 1. Section through a diseased leaf, showing the mycelium in the tissues and two external spore-bearing hyphæ projecting through a stoma.
 FIG. 2. Conidia and conidiophores more enlarged. The epidermis and stoma are shown in the surface view. (F. L. Scribner, del.)
 FIG. 3. A series of drawings, representing successive stages in the development of a conidium: *a*, end of conidiophore slightly swollen; *b*, *c*, successive stages in the growth of the conidium; *d*, the conidiophore has pushed on, leaving the conidium already formed attached to an enlargement below the point, and has begun to form another conidium on the end; *e*, the first-formed conidium has fallen from the enlargement of the conidiophore at *g*, and the second conidium formed is in turn left behind by the growing conidiophore, which is forming a third conidium at the end.
 FIG. 4. Mycelium in the tissue of a potato tuber. (F. L. S., del.)
 FIG. 5. Series of figures representing the germination of a conidium: *a*, mature conidium; *b*, same, after remaining some time in water, five vacuoles have made their appearance; *c*, the contents are segmented into five distinct parts, each of which is provided with a vacuole; *d*, the exospore has ruptured and the zoospores are in the act of escaping; *e*, free zoospore; *f*, same a little later, the vacuoles have become smaller; *g*, same, still later, the cilia are gone and the zoospore has come to rest; *h*, beginning of germination; *i*, *k*, *l*, successive stages in the growth of the germ tube or first mycelium filament; *m*, entrance of germ tube into the leaf through a stoma.
 FIG. 6. Section of leaf, showing the penetration of a germ tube into the epidermis through the cell wall.

PLATE III.

BLACK-ROT OF TOMATO—MACROSPORIUM SOLANI, RAV.

- FIGS. 1 and 2. Diseased fruit in different stages of decay, showing the black appearance and sinking in of the decayed portions. (R. Cowing, fecit.)
 FIG. 3. Tuft of conidiophores, showing characteristic protuberances on which spores have been borne. (E. A. Southworth, del.)
 FIG. 4. End of branched conidiophore with spore attached to one of the branches. (E. A. S., del.)
 FIG. 5. Spores. (E. A. S., del.)
 FIG. 6. Germinating spores. (E. A. S., del.)
 FIG. 7. Tuft of conidiophores without the protuberances shown in Fig. 3: *a*, mycelium. (E. A. S., del.)

PLATE IV.

TOMATO DISEASES—FUSARIUM SOLANI, MART., AND CLADOSPORIUM FULVUM, CKE.

- FIG. 1. Ends of conidiophores bearing macroconidia: *a a*, immature; and *b*, mature macroconidia. (R. C., del.)
 FIG. 2. Branch of a hypha that has run over the surface sending out upright conidiophores; the macroconidia on the latter are immature. (R. C., del.)

- FIG. 3. Portion of branched conidiophores from one of the fruiting tufts that break through the epidermis: *b*, conidiophore; *a*, immature macroconidia. (R. C., del.)
- FIG. 4. Mature macroconidia. (R. C., del.)
- FIG. 5. Germinating macroconidia: *a*, only a few hours in water, one of the segments has swollen; *b*, later stage; *c*, spore forming a microconidium at the end. (R. C., del.)
- FIG. 6. Microconidia: *a*, immature forms; *b*, mature, showing rough exospore.
- FIG. 7. Germinating microconidium. (R. Prestele, del.)
- FIG. 8. Mycelium between the cells of the tomato. (R. C., del.)
- FIG. 9. Tuft of conidiophores of *Cladosporium fulvum*. (E. A. S., del.)
- FIG. 10. Spores and ends of conidia-bearing branches: *a*, *b*, *c* are probably ends of fruiting branches capable of breaking up into spores; *d*, germinating spores. (E. A. S., del.)
- FIG. 11. Peculiar and characteristic forms of conidiophores, showing method of branching and bearing spores. (E. A. S. del.)

[PLATE V.

BROWN-ROT OF CHERRY—*MONILIA FRUCTIGENA*, PERS.

- FIG. 1. Upper side of a diseased leaf, showing the irregular brown spots made by the fungus. (R. C., fecit.)
- FIG. 2. Lower side of a diseased leaf. (R. C., fecit.)
- FIG. 3. Bunch of cherries, some of which are attacked by the fungus: *a*, cherry which was diseased the year before, and has hung on the tree over winter; *b*, green, healthy cherries; *c*, diseased cherries with the blossom (*d*) clinging to the fruit. (R. C., fecit.)

PLATE VI.

BROWN-ROT OF CHERRY—*MONILIA FRUCTIGENA*, PERS.

- FIG. 1. Fruiting tuft that has broken through the epidermis—from apple. (E. A. S., del.)
- FIG. 2. Mycelium found in dried specimens of diseased apple: *a*, showing passage through cell wall; *b*, coarse hyphae passing into finer ones. (E. A. S., del.)
- FIG. 3. Cell of peach, showing the fine mycelium in the cell. (E. A. S., del.)
- FIG. 4. Piece of coarse mycelium from fresh peach; the protoplasm is so full of vacuoles as to give it the appearance of a network. (E. A. S., del.)
- FIG. 5. Germinating spores from the same fungus on plum, showing fusion of germ filaments, both uniting the spores themselves and the main filaments proceeding from them. (E. A. S., del.)
- FIG. 6. Germinating spores from the fungus on peach, shown in optical section. (E. A. S., del.)
- FIG. 7. Spores from peach, showing some in the first stages of germination: at a two germ-tubes are approaching preparatory to fusion. (E. A. S., del.)

PLATE VII.

POWDERY MILDEW OF CHERRY—*PODOSPHAERA OXYCANTHA* (DC.), DBY.

- FIG. 1. Peritheciium from the fungus on *Prunus cerasus*, viewed nearly from above, showing the septate appendages. The appendages are usually a little longer than here represented. (M. B. Waite, del.)
- FIG. 2. A well developed appendage from a peritheciium on *Crataegus tomentosa* (much enlarged). (M. B. W., del.)
- FIG. 3. Ascus from a peritheciium on *Prunus cerasus*, showing the contained ascospores: *b*, one of the ascospores, showing the granular protoplasmic contents. (M. B. W., del.)
- FIG. 4. A portion of the mycelium with conidiophores and rows of conidia (from peach leaves): *a*, conidiophores; *b*, conidia; *c*, four nearly mature conidia, with the upper one about to be detached; *d*, three mature conidia, detached. (E. A. S., del.)

- FIG. 5. Section through the epidermis of an infested peach leaf, showing a short piece of the mycelium (*a*) and a haustorium (*b*) extending into an epidermal cell. (E. A. S., del.)
- FIG. 6. A pycnidium and portions of the mycelium of *Cicinobolus Cesatii*, DBY., showing the mycelium inside that of the *Podosphara*. (M. B. W., del.) The spores are seen exuding from the apex of the pycnidium. (Drawings all made from nature by the aid of the camera lucida.)

PLATE VIII.

LEAF BLIGHT AND CRACKING OF THE PEAR—*ENTOMOSPORIUM MACULATUM*, LÉV.

- FIG. 1. End of branch, showing leaves with characteristic spots caused by the fungus. (R. C., fecit.)
- FIG. 2. Diseased fruit, showing spots and crack. (R. C., fecit.)

PLATE IX.

LEAF BLIGHT AND CRACKING OF THE PEAR—*ENTOMOSPORIUM MACULATUM*, LÉV.;
LEAF SPOT OF ROSE—*CERCOSPORA ROSÆCOLA*, PASS.

- FIG. 1. Section of leaf through a disease spot, showing a fruit pustule containing spores in different stages of development. (E. A. S., del.)
- FIG. 2. Young spores, showing method of development and attachment to the mycelium. (E. A. S., del.)
- FIG. 3. Mature spores. (E. A. S., del.)
- FIG. 4. Spermogonium form often found on the same leaves with *Entomosporium*, surface view. (E. A. S., del.)
- FIG. 5. Section of same. (E. A. S., del.)
- FIG. 6. Mature or ascosporous stage of the fungus: *a*, ascus containing the two-celled ascospores; *b*, empty ascus with pore open at the apex through which the spores have escaped; *c*, germinating ascospores; *d*, same, more advanced; *e*, paraphyses. (After Sorauer.)
- FIG. 7. Tuft of conidiophores and conidia of *Cercospora rosæcola*: *a*, spore; *b*, conidiophore. (E. A. S., del.)
- FIG. 8. Spores from fungus collected after a spell of wet weather, which probably accounts for the difference between them and the spores in Fig. 7. (E. A. S., del.)

PLATE X.

PLUM POCKETS—*TAPHRINA PRUNI* (ECKL.), TUL.

- FIG. 1. Branch, natural size, showing the appearance of the pockets. (R. C., del.)
- FIG. 2. Surface view of the network of mycelium between the epidermal cells and the cuticle.
- FIG. 3. Section through the outer surface of the pocket, showing the mycelium in the tissues and between the epidermal cells and the network in section above these. (After Sorauer.)
- FIG. 4. Section, showing young asci which have not yet ruptured the cuticle. (E. A. S., del.)
- FIG. 5. Section showing asci in different stages, some of them mature and containing spores, the others resemble those of Fig. 4. (E. A. S., del.)
- FIG. 6. Asci, more enlarged and separated from the others, showing septum, pedicels, and spores. (E. A. S., del.)

PLATE XI.

APPLE RUST—*ROESTELIA PIRATA*, THAX.?

- FIG. 1. Apple leaves, showing the æcidium stage: *a*, upper side of leaf; *b*, under side. (R. C., fecit.)
- FIG. 2. *Gymnosporangium macropus* or Cedar apple. (R. C., fecit.)

PLATE XII.

APPLE RUST—*RCESTELIA PIRATA*, THAX.

- FIG. 1. Fragment of leaf, showing the under side with the cluster cups. The peridia are slit and turned back, as is characteristic of this species. (R. C., del.)
- FIG. 2. *Æcidio* spores, showing thin places in the cell wall for the passage of the germ tubes: *a a*, thin places. (Drawing made from specimens that had been soaked in a strong potash solution.) (E. A. S., del.)
- FIG. 3. Germinating spores: *a a*, germ tubes. (E. A. S., del.)
- FIG. 4. Spores of *Gymnosporangium*. (E. A. S., del.)
- FIG. 5. Germinating spore of same: *a a*, sporidia. (After Farlow.)
- FIG. 6. Germinating sporidia. (E. A. S., del.)

PLATE XIII.

NEW GRAPE DISEASE—*SEPTOSPORIUM HETEROSPORUM*, ELLIS AND GALLOWAY.

- FIG. 1. Tuft of conidiophores of *Septosporium Fuckelii*. (E. A. S., del.)
- FIG. 2. Spores of same. (E. A. S., del.)
- FIG. 3. Tuft of conidiophores of *Septosporium heterosporum*. (E. A. S., del.)
- FIG. 4. Spores of same. (E. A. S., del.)
- FIG. 5. Spermogonium of same, with tuft of conidiophores growing from apex of capsule. (E. A. S., del.)
- FIG. 6. Section through a spermogonium, showing the spermatia and manner in which they are borne. (E. A. S., del.)
- FIG. 7. Spermatia, much enlarged. (E. A. S., del.)

PLATE XIV.

MAPLE-LEAF BLIGHT—*PHYLLOSTICTA ACERICOLA*, C. & E.

- FIG. — Showing the spots on both sides. (R. C., fecit.)

PLATE XV.

MAPLE-LEAF BLIGHT—*PHYLLOSTICTA ACERICOLA*, C. & E.; SYCAMORE DISEASE—*GLEOSPORIUM NERVISEQUUM*, SACC.

- FIG. 1. Section through pycnidium of *Phyllosticta acericola* on *Acer dasycarpum*. (E. A. S., del.)
- FIG. 2. Germinating spores. (E. A. S., del.)
- FIG. 3. Mycelium: *a*, in *Acer rubrum*; *b*, in *Acer dasycarpum*. (E. A. S., del.)
- FIG. 4. Section through mature pustule of *Discella platani* on bark of *Platanus*. (E. A. S., del.)
- FIG. 5. *Gleosporium nervisequum* on leaf. (E. A. S., del.)
- FIG. 6. Spores. (E. A. S., del.)

PLATE XVI.

POPLAR LEAF RUST—*MELAMPSORA POPULINA*, LÉV.

- FIG. 1. Section through sorus containing uredospores. (E. A. S., del.)
- FIG. 2. Section through sorus containing teleutospores. (M. B. W., del.)
- FIG. 3. Uredospores and paraphyses: *a a a*, spores in optical section; *b*, surface view; *c c*, paraphyses; *d*, immature spore. (E. A. S., del.)
- FIG. 4. Teleutospores: *a a*, in optical section; *b*, surface view. (M. B. W., del.)

PLATE XVII.

HEALTHY PEACH SHOOT—DELAWARE.

Robust terminal shoot. Taken August 20, 1888, from a healthy tree in orchard of Joseph McDaniel, Dover, Del. Reduced to about one-fifth natural size.

PLATE XVIII.

DISEASED PEACH SHOOTS—DELAWARE.

Shoots from an obscure bud on limb of a tree badly diseased by yellows: such shoots usually remain *entirely* unbranched in healthy trees. Taken September 3, 1887, from orchard E. P. Selmser, Dover, Del. Reduced to about seven twenty-fourths natural size.

PLATE XIX.

HEALTHY AND DISEASED PEACHES—DELAWARE.

Stump the World or Old Mixon peaches, taken August 20, 1888, from orchard of Joseph McDaniel, Dover, Del. Natural size.

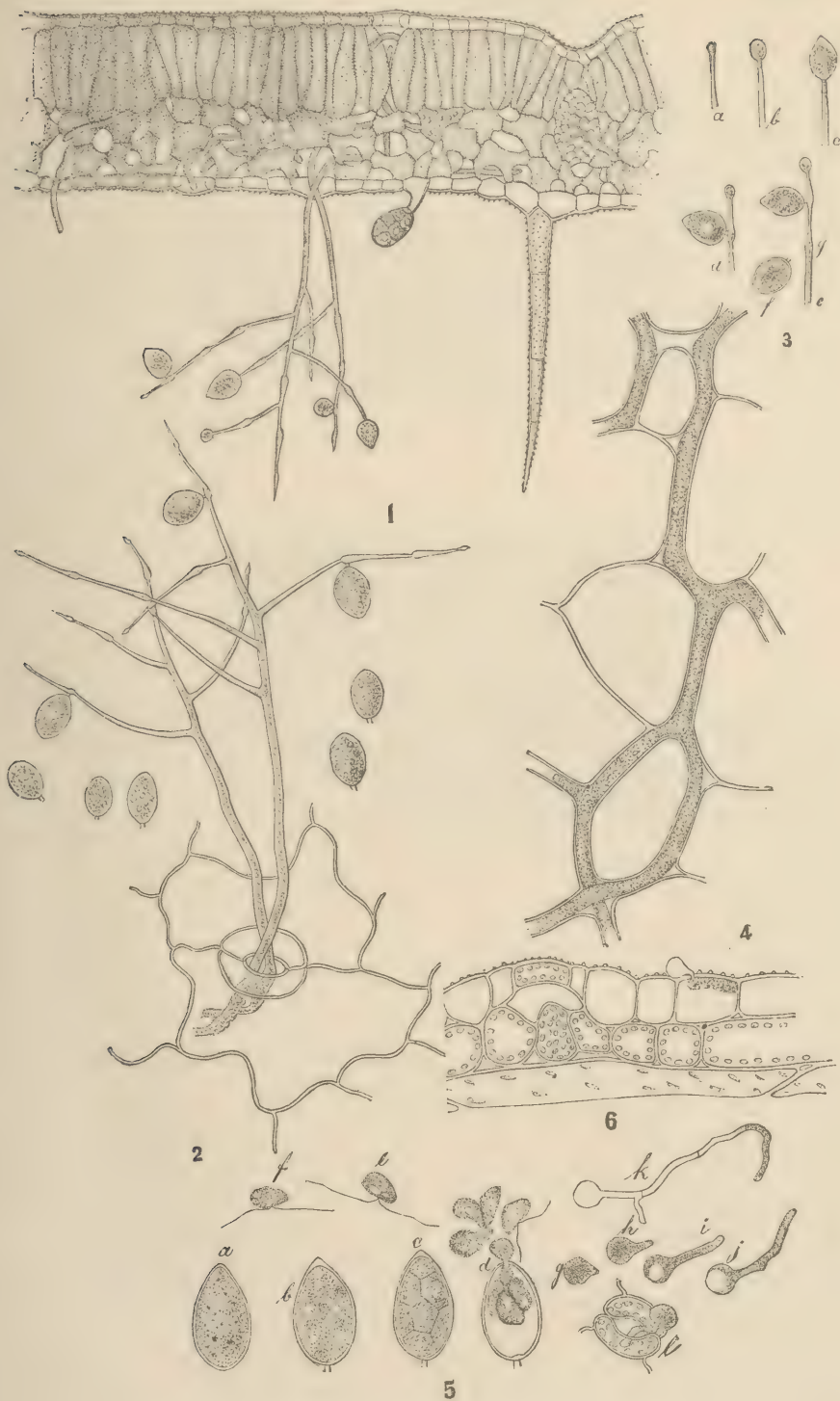
No. 1. green and healthy; No. 2, from a neighboring tree, red-spotted and prematurely ripe.



2.

DOWNY MILDEW AND ROT OF POTATO.

Phytophthora infestans, D. By.



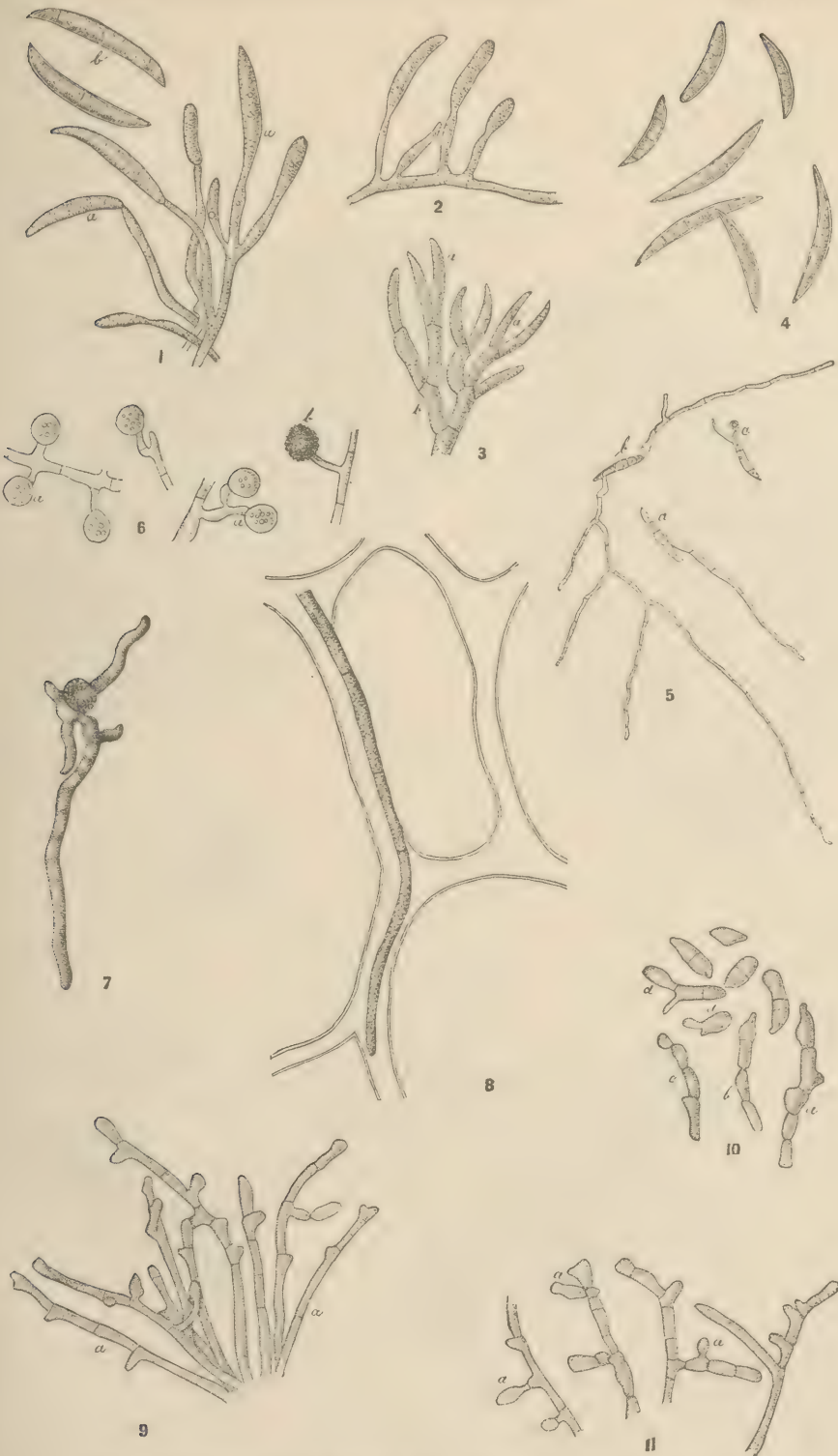


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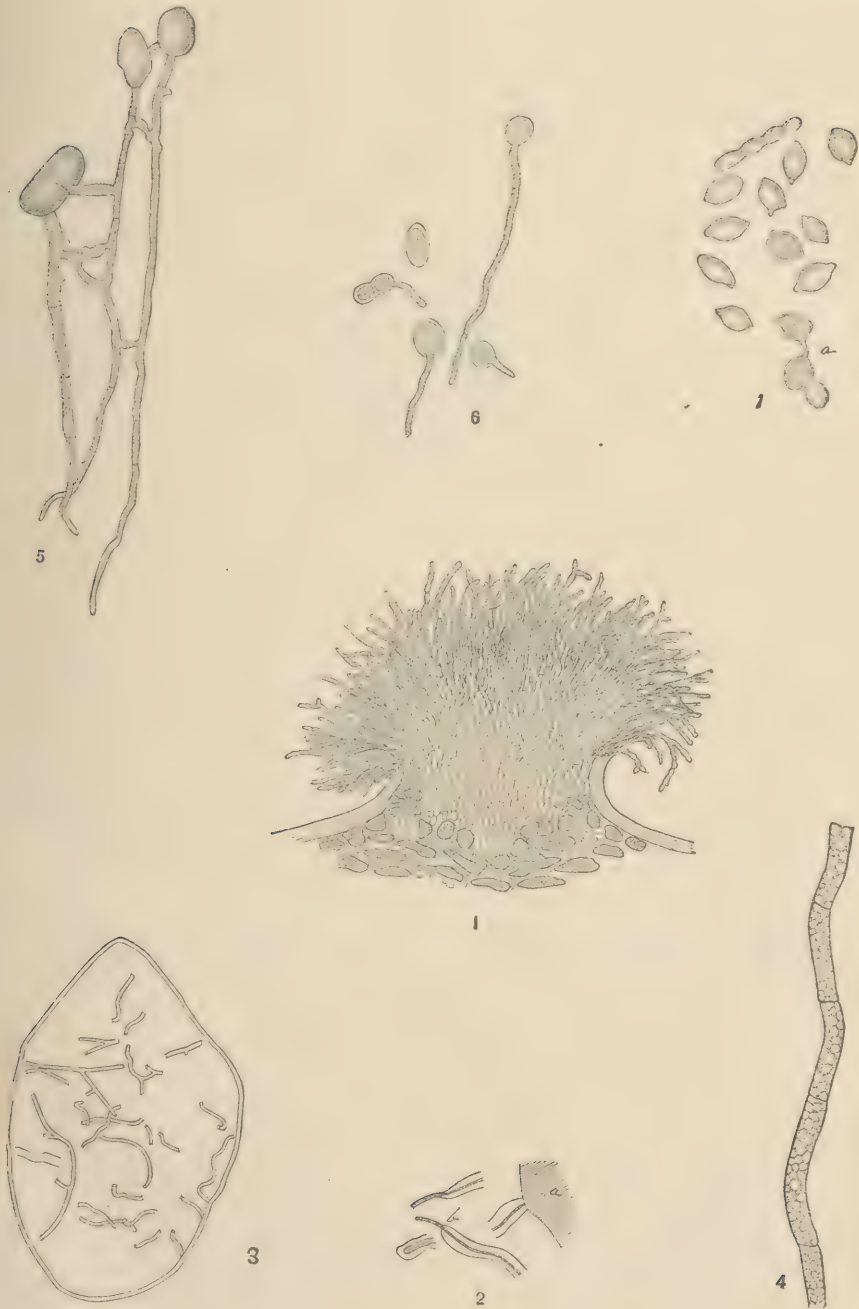
Macro



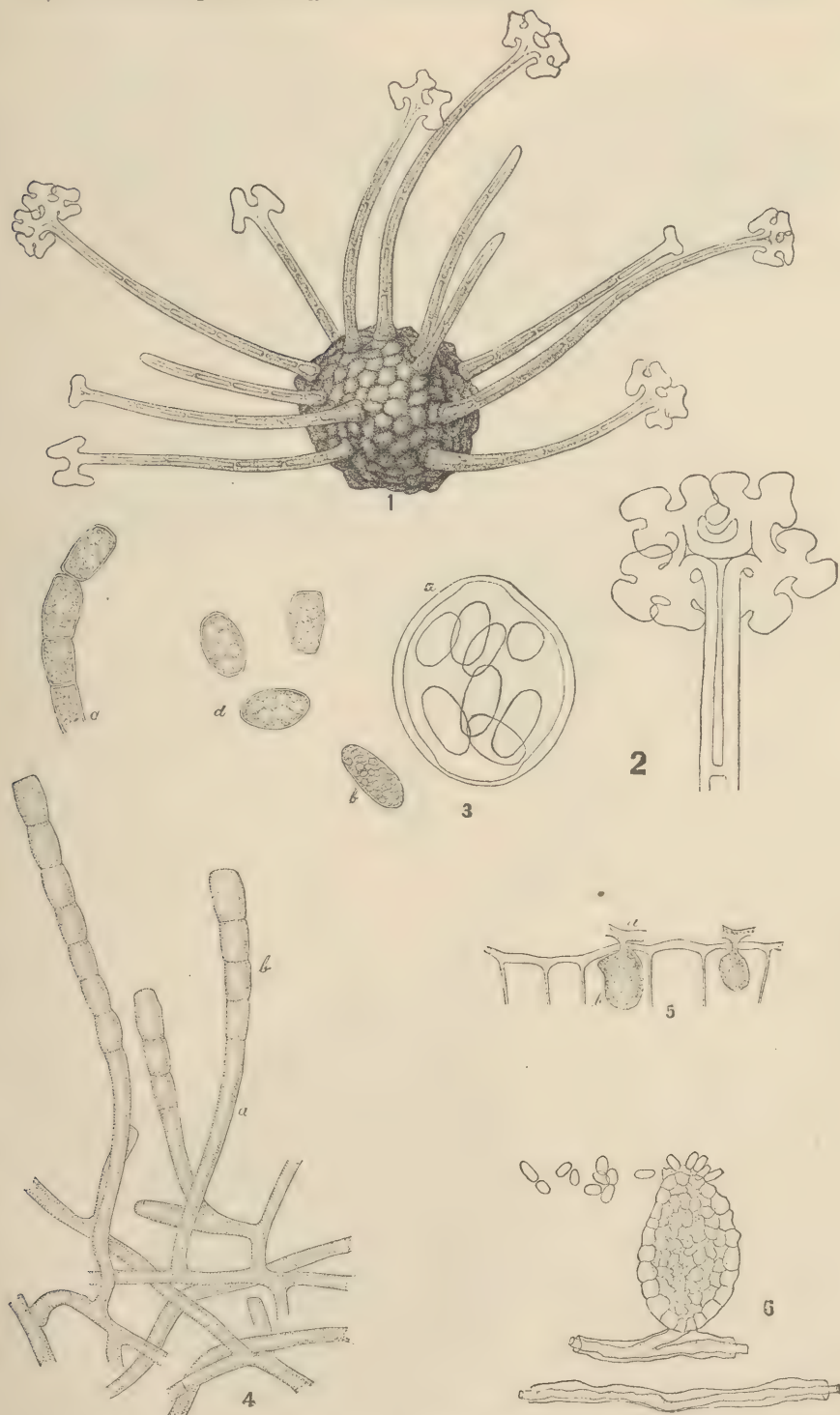
TOMATO DISEASES (*FUSARIUM SOLANI*, MART., AND *CLADOSPORIUM FULVUM*, CKE.).



BROWN ROT OF CHERRY.
Monilia fructigenum Pass.



BROWN ROT OF THE CHERRY (*MONILIA FRUCTIGENA*, PERS.).



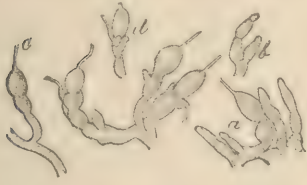
POWDERY MILDEW OF CHERRY (*PODOSPHAERA OXYCANTHA*. D BY.).



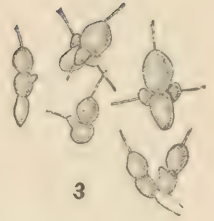


LEAF EIGHT AND MARKING OF THE ORANGE

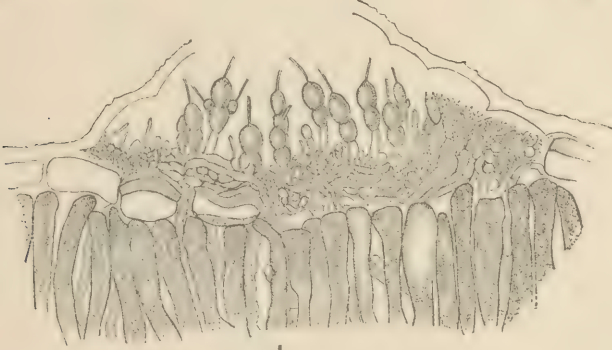
PLATE VIII. — THE ORANGE.



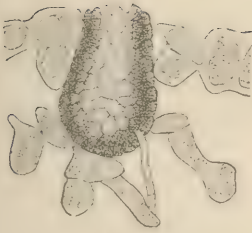
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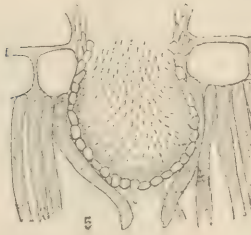
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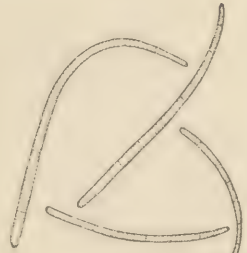
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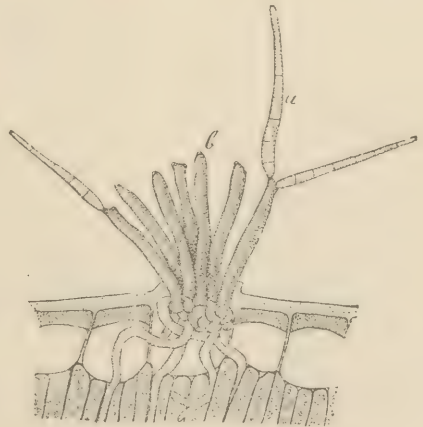
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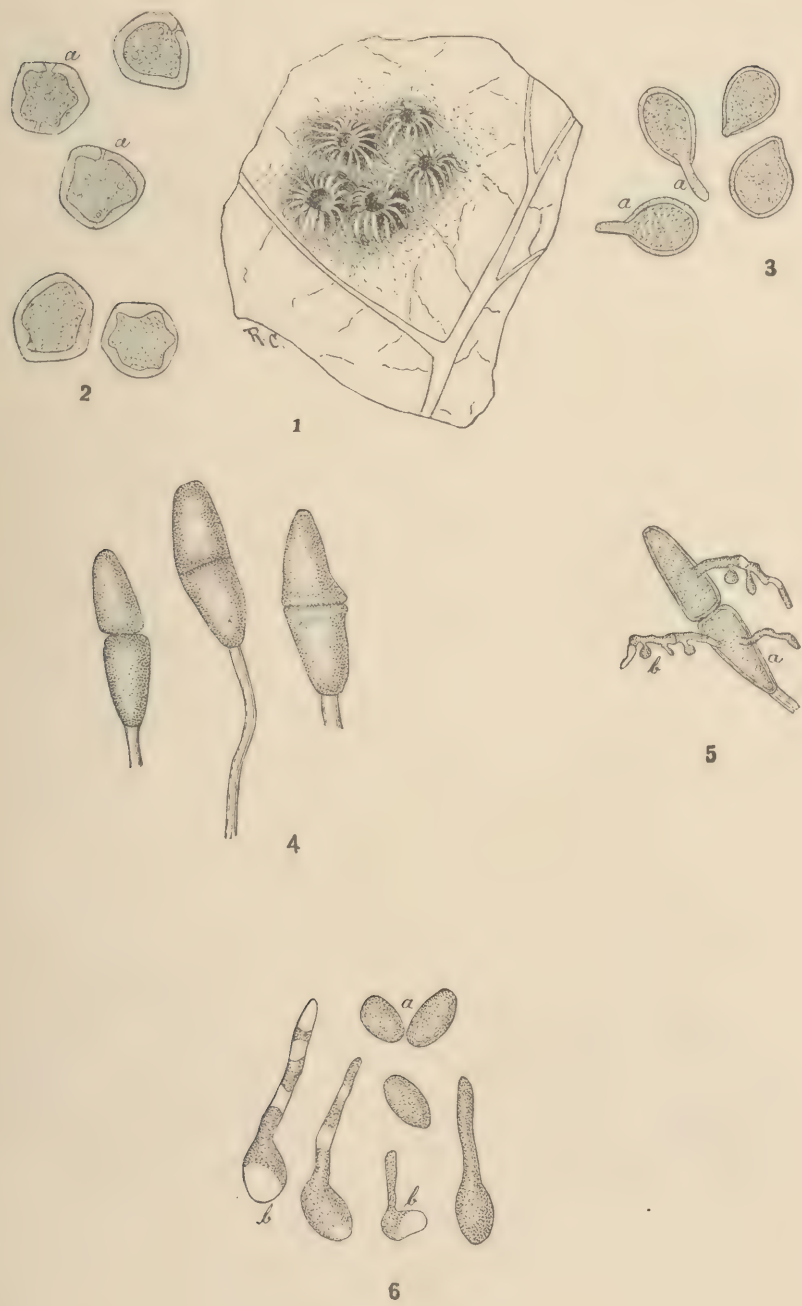
LEAF BLIGHT OF PEAR AND LEAF SPOT OF ROSE (*ENTOMOSPORIUM MACULATUM*, LÉV., AND *CERCOSPORA ROSÆCOLA* PA3S.).



PLUM POCKETS (*TAPHRINA PRUNI*, TUL.).



APPLE LEAF RUST AND CEDAR APPLE.
Roestelia pyrata, Thax. and *Gymnosporangium macrosporus*, Link..





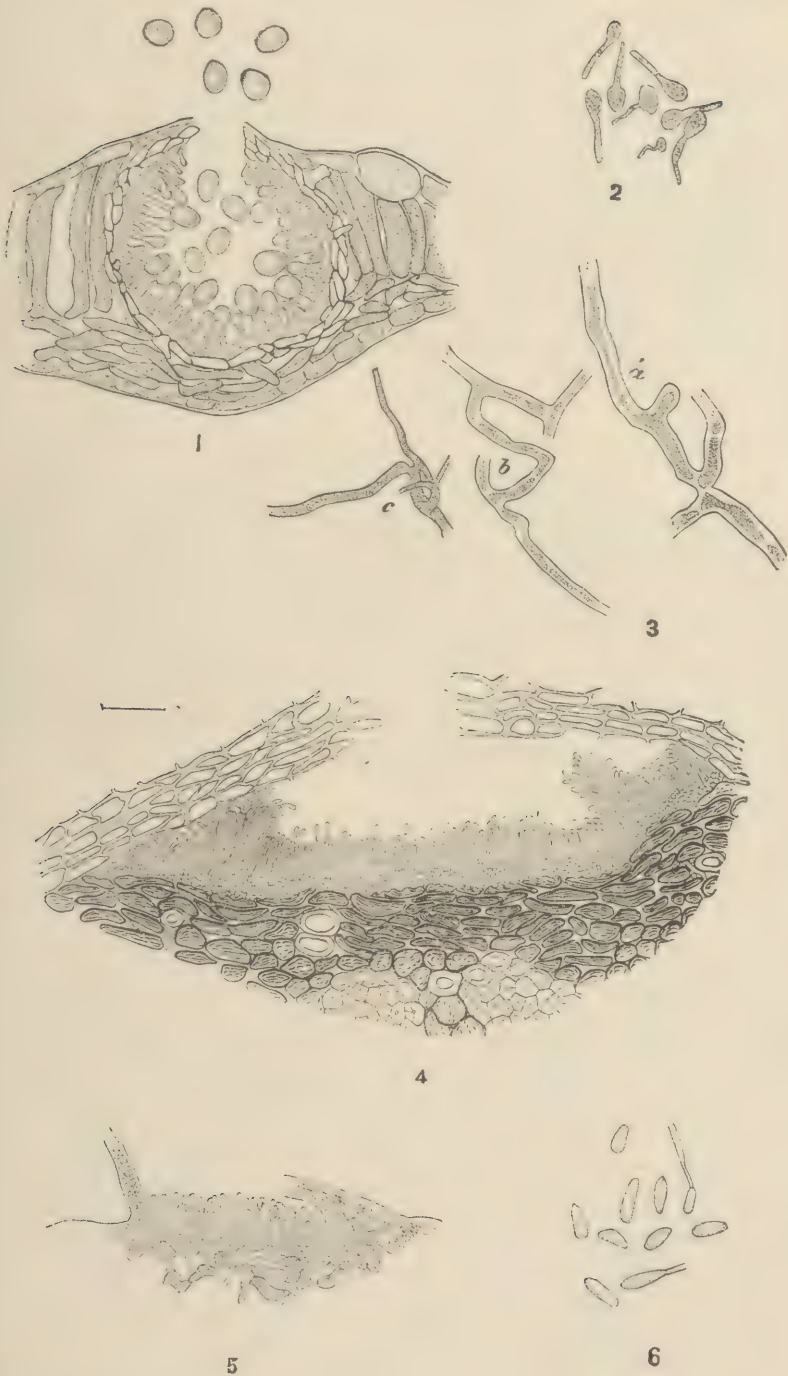
GRAPE SEPTOSPORIUMS (*SEPTOSPORIUM FUECKELII*, THÜM.; *S. HETEROSPORUM*, ELL. & GALL.).



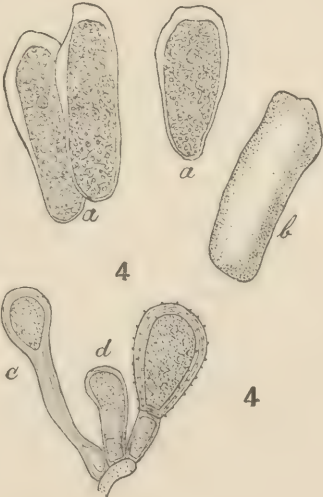
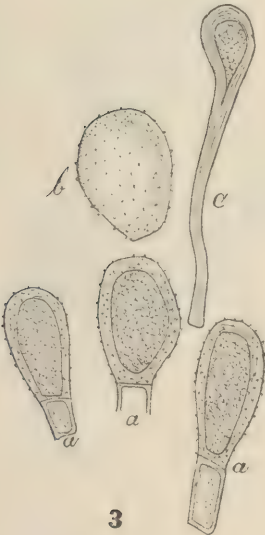
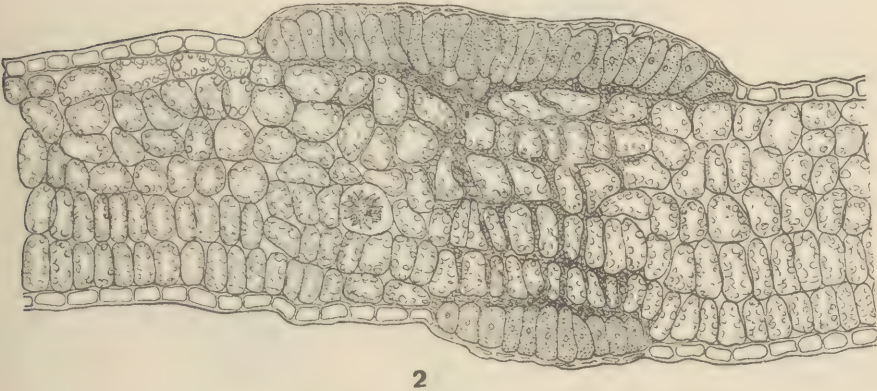
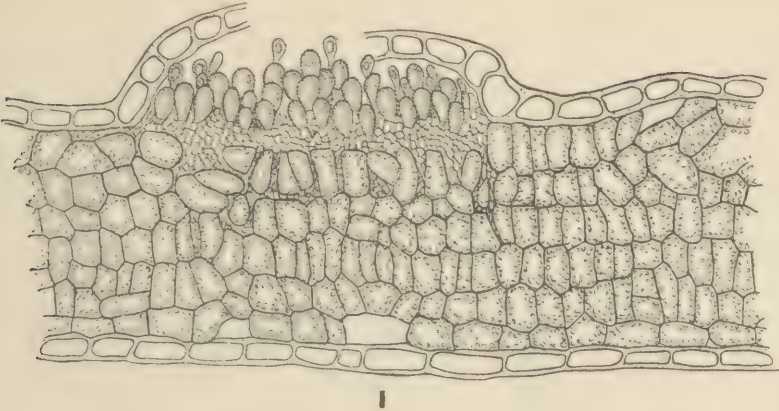
LEAF-SPOT DISEASE OF THE MAPLE.

PHYLLOSTICTA ACERICOLA. C. & E.

THE MATCH LITHO. CO. N. Y.



MAPLE LEAF BLIGHT AND SYCAMORE DISEASE (PHYLLOSTICTA ACERICOLA, C. & E., AND GLÆOSPORIUM NERVISEQUUM, SACC.).



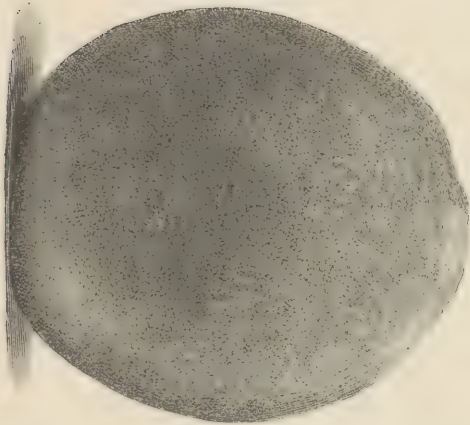
POPLAR LEAF RUST (MELAMPSORA POPULINI, LÉV.).



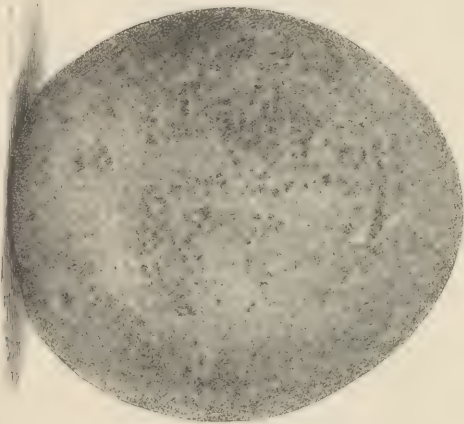
HEALTHY PEACH SHOOT—DELAWARE.



DISEASED PEACH SHOOTS—DELAWARE.

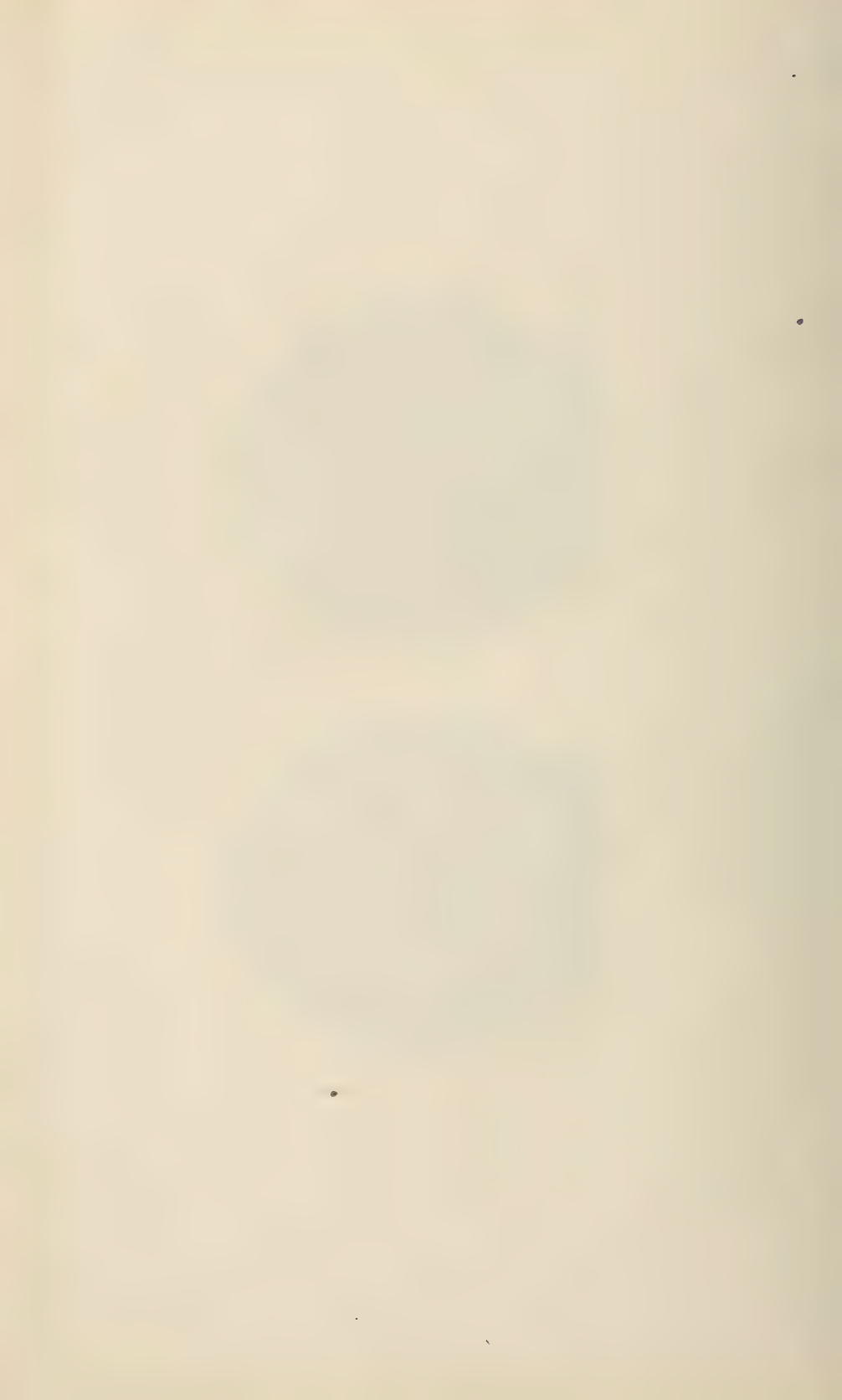


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HEALTHY AND DISEASED PEACHES—DELAWARE.





MAP
SHOWING THE DISTRIBUTION AND SEVERITY
OF
POTATO ROT
IN THE UNITED STATES IN 1885,
AND ALSO APPROXIMATELY
THE DISTRIBUTION OF THE POTATO ITSELF.
Prepared from Department Returns, and from Vol. III U. S.
Census, 1880.
By ERWIN F. SMITH.

LEGEND.

Product of 149,000,000 Bushels in 1879.
" " 18,000,000 " " 1879.
" " 3,000,000 " " 1879.

The enclosed areas represent Districts from which reports have been received; the counties in which the reported per cent. of rot was about the same being grouped together.

The heavy black figures represent the average per cent. of rot within each area.

The small red figures indicate the number of reports received.
In most cases each report is an average derived from the statement of many individuals.

INDEX.

Acrostolagmus, 389.
Actinonema rosae, 364, 365.
 Additional notes on celery-leaf blight, 336, 398.
Aecidium, 371, 374.
 Berberidis, 370, 371.
 Form-genus of, 370.
 Piratum, 378.
Agrosporium fructigenum, 349.
 Alabama, treatment of powdery mildew in, 383.
Alphitomorpha trydactyla, 353.
 Ammoniacal carbonate of copper, formula for, 331.
Ampelomyces quinquatus, 355.
 Anderson, F. W., report of, 325, 326.
 Anthracnose, 332.
 Apple rusts, 370.
 Bibliography of, 381.
 Gymnosporangium forms of, 372.
 On wild crab in 1887, 375.
 Relations to *Gymnosporangia*, 375, 379.
 Roestelia forms of, 374.
 Roestelia on apples, 378.
 Spermogonial forms of, 374.
 Treatment of, 379.
 Arkansas, treatment of black-rot in, 332.
Ascomyces pruni, 366, 367, 369.
 Bellows for applying powders, 328.
 Bibliography of:
 Apple rusts, 381.
 Cherry mildew, 357.
 Cottonwood rusts, 392.
 Leaf-disease and cracking of the pear, 364.
 Leaf-spot disease of the maple, 386.
 Plum pockets, 369.
 Sycamore disease, 389.
 Black-rot of grapes:
 Bulletins on, 325.
 Date of first appearance of, 330, 332.
 Experiments in treatment of, by special agents, 326.
 May be prevented, 334.
 Preventive treatment of, 335.
 Treatment of, 327.
 Treatment of, in Arkansas, 332.
 Black-rot of the tomato, 339.
 Cause of, 341.
 Conditions favoring the disease, 340.
 Effect of pruning on, 346.
 Effect of soil and fertilizers on, 346.
 External characters of, 340, 345.
 Fusarium in, 342.
 Inoculation experiments with, 344.
 Life history of, 343.
 Losses from, 340, 346.
 Macrosporium in, 342.
 Name of, 339.
 Progress of, during the season, 346.
 Report of Dr. H. S. Bowers on, 345.
 Treatment of, 345, 346.
 Blight powder for mildew and rot of potato, 339.
 Blue stone. (See Sulphate of copper.)
 Bordeaux mixture:
 As a preventive of black-rot, 330.
 Comparison of treated and untreated vines, 329, 330.
 For downy mildew and rot of potato, 339.
 How to prepare, 327, 328, 330, 331.
 Striking effects of, 529.
 Bowers, Dr. Homer S., report of, 345.
 Brown-rot of grapes, 323.
 Brown-rot of cherry. (See *Monilia fructigena*.)

Bulletin:
 No. 5, on downy mildew and black-rot of grape-vine, 325.
 No. 7, on black-rot in America, 325.
 No. 8, on some practical work of the Section, 325.
 No. 9, on peach yellows, 325.
 California:
 Peach yellows not in, 393.
 Powdery mildew of the cherry in, 353.
 Sycamore disease in, 387.
 Celery-leaf blight:
 Additional notes on, 336, 398.
 In 1881, 398.
 Influence of climate and shade on, 399.
 Treatment of, 399.
Cercospora apii, 398.
Cercospora roseicola, 364.
 At Columbia, Mo., 364.
 Differs from black-spot, 364.
 External characters of, 365.
 Microscopic characters of, 365.
 Treatment of, 365.
 Cherry, brown-rot of (see Brown-rot of the cherry), 349.
Chrysomyxa, 374.
Cincinobolus Cessatii, 355.
 Circular distributed among grape-growers, 327.
Cladosporium fulvum:
 Botanical characters of, 348.
 Cause of, 347.
 Inoculation experiments with, 348.
 In England, 347.
 In nurseries at Vineland, N. J., 347.
 Treatment of, 348.
 Connecticut, peach yellows in, 393.
 Copperas for washing vines, 333.
 Cottonwood, leaf-rust of (see *Melampsora populina*), 390.
Cytispora platani, 389.
 David's powder:
 Formula for, 328.
 For tomato-rot, 340.
 Delaware, peach yellows in, 398.
Discella platani, 388, 389.
 Eau celeste:
 Formula for, 327, 328, 331.
 For grape mildew, 333, 335.
 For mildew and rot of potato, 339.
 How to prepare, 327.
 Modified formula, how to prepare, 327.
Entomosporeum brachiatum, 358.
Entomosporeum maculatum, 357, 358, 359.
 Bibliography of, 364.
 Effects and losses from, 357.
 External characters of, 359.
 Geographical distribution of, 358.
 History of, 358.
 Hosts of, 357.
 Microscopic characters of, 359.
 Treatment of, 362.
 Winter form of, 361.
Entomosporeum mespili, 359.
Erysiphe, 352, 355.
Erysiphe oxycanthae, 353.
Eureka sprayer, 328, 331, 363.
Exoascus pruni, 366, 369.
 Experiments in the treatment of grape-vine diseases in 1888, 326.
Fenestella platani, 389.
 Field work, necessity for, 335.

- Fusarium nervisequum*, 368, 389.
Fusarium solani, 341, 342, 343, 344.
Georgia:
 Peach yellows in, 393.
 Smithville, leaf blight of pear at, 357.
Gloeosporium nervisequum, 387.
 Bibliography of, 389.
 Botanical characters of, 388.
 Geographical distribution of, 387.
 History of, 387.
 Hosts of, 387.
 Possible relations to other forms, 389.
 Treatment of, 389.
Grapes, bagging of, 329.
Gymnosporangium, 372, 374.
Biseptatum, 373, 374, 375.
Clavipes, 375, 376, 378.
Clavariaeforme, 375, 376, 378.
 Conditions favoring development of, 377.
Conteum, 375.
 Destruction of hosts of, 379.
Ellisti, 373, 375, 376, 378, 380.
 External characters of, 376.
Fusum, 375.
 Genus of, 370, 372, 377.
 Geographical distribution of, 376.
Globosum, 374, 375.
 History of, 372.
 Hosts of, 370, 379.
 Injury to hosts from, 373.
Juniperi-virginianae, 376.
Macropus, 374, 375, 376, 378, 379, 380.
 Microscopical characters of, 377.
 Species, characters of, 372.
 Spores, germination of, 377.
 Synonyms, 376.
Herbarium, additions to, 325.
Hosts of:
Entomosporium maculatum, 358.
Gloeosporium nervisequum, 387.
Gymnosporangium, 372, 375.
Melampsora populina, 391.
 Peach yellows, 393.
Phyllosticta acericola, 383.
Podosphera oxycantha, 353.
Rastelia, 375.
Septosporium heterosporum, 381.
Taphrina pruni, 368.
Hymenula platani, 387, 389.
Hypomyces, 342.
Illinois:
 Cherry mildew abundant in, 356.
 Cobden, leaf-blight of pear at, 357.
 Leaf-spot disease of maple in, 383.
 Peach yellows in, 393.
 Sycamore disease in, 387.
Indiana:
 Black-spot of tomato in, 340, 345, 346.
 Sycamore disease in, 387.
 Infection by black-rot, dates of, 329.
Iowa, Ames:
 Plum pockets at, 368.
 Tomato disease at, 348.
Jaeger, Hermann, experiments of, 329.
Kansas:
 Leaf-spot disease of the maple in, 383.
 Plum pockets in, 366.
Kentucky:
 Plum pockets in, 366.
 Sycamore disease in, 387.
Leaf-blight and cracking of the pear. (See *Entomosporium maculatum*.)
Leaf-rust of cottonwoods. (See *Melampsora populina*.)
Leaf-spot of the rose. (See *Cercospora roseicola*.)
Leaf-spot disease of the maple. (See *Phyllosticta acericola*.)
Letter of instruction to agents, 326.
Liquid grison for powdery mildew of cherry, 356.
Liquid remedies, formulae for, 328.
Liver of sulphur:
 Effect on *Monilia* spores, 352.
 For powdery mildew of the grape, 334.
Macrosporium tomatum, 341, 342, 343, 344, 345.
 Maple, disease of, 383.
Maryland:
 Peach yellows in, 393.
 Sycamore disease in, 387.
Massachusetts Agricultural College, tomato-rot at, 341.
Melampsora populina, 390.
 Bibliography of, 392.
 Botanical characters of, 391.
 Effects on hosts of, 390.
 Family characters of, 390.
 Hosts and distribution of, 391.
 Treatment of, 392.
Michigan:
 Kalamazoo favorable for celery, 399.
 Peach yellows in, 393.
 Tomato-rot in, 340.
Microscopic mounts, 325.
Microsphaera fulvofulcrata, 353.
Middle Bass, Ohio, experiments at, 333.
Mildew of cherry. (See *Podosphera oxycantha*.)
Mildew of grape, 323, 330.
 Treatment for, 327.
Mildew of potato. (See *Phytophthora infestans*.)
Mildew of tomatoes, 347.
Mississippi:
 Sycamore disease not in, 387.
 Tomato-rot in, 340.
Missouri:
 Cherry mildew in, 354.
 Columbia, leaf-spot of rose at, 364.
 Leaf-spot disease of maple in, 383.
 Neosho, experiments at, 329.
 Special agent in, 326.
 Sycamore disease not in, 387.
Monilia fructigena, 349.
 Botanical characters of, 350.
 Cause of, 349.
 Distribution of, 349.
 External characters of, 350.
 Spores, vitality of, in, 351.
 Treatment of, 352.
Montana, collection of fungi in, 325, 326.
Mortheria mespiti, 358.
New England, leaf-spot disease of maple in, 383.
New York:
 Leaf-spot disease of maple in, 383.
 Peach yellows in, 393.
New York Agricultural Experiment Station:
 Experiments of gooseberry mildew at, 356.
 Tomato-rot at, 341.
Nozzles:
 Nixon's climax, 333, 352, 386.
 Riley cyclone, 328, 386.
 Where manufactured, 352.
Ohio:
 Middle Bass, experiments at, 333.
 Plum pockets in, 366.
 Sycamore disease in, 387.
Oidium:
Fructigenum, 329.
Wallrothii, 349.
Ontario, peach yellows in, 393.
Oospora candida, 349.
Peach, root-knot in, 395.
Peach yellows, 393.
 Cause of, 395.
 Diseases mistaken for, 395.
 Former severity of, 393.
 Germ theory of, 396.
 Inoculations of, 396.
 Present distribution of, 393.
 Present severity of, 393.
 Remedies for, 398.
 Replanting orchards diseased by, 398.
 Symptoms of, 394.
 Trees affected by, 393.
 When and where discovered, 393.
Pearson, Col. A. W.:
 Experiments by, 328.
 Winter treatment in vineyard of, 335.
Pennsylvania, peach yellows in, 393.
Peronospora viticola, 328, 330, 333.
 Treatment of, 333.
Phoma minima, 384, 386.
Phyllosticta acericola, 383, 384, 386.
 Bibliography of, 386.
 Botanical characters of, 385.
 Differences on different hosts, 385.
 Effects of, 383.
 External characters of, 384.
 Geographical distribution of, 383.
 History of, 384.
 Hosts of, 383.
 Treatment of, 386.

- Phytophthora infestans*, 337.
 Conditions favoring, 338.
 Disinfection of tubers for, 338.
 Distribution of, 337.
 Germination of spores of, 338.
 On the leaves, 337.
 On the stems, 337.
 On the tubers, 337.
 Origin of, 337.
 Susceptibility of varieties to, 337.
 Treatment of, 338.
- Plum pockets. (See *Taphrina pruni*).
- Podosphaera*:
 Minor, 353.
 Myrtilina, 353.
 Trydactyla, 353.
- Podosphaera oxycanthæ*, 352.
 Bibliography of, 357.
 Botanical characters of, 354.
 Conditions favoring development of, 356.
 External characters of, 354.
 History of, 353.
 Host plants and distribution of, 353.
 Parasite on, 355.
 Treatment of, 356.
- Podosoma macropus*, 376.
- Potato-rot, 337.
- Potatoes:
 Hilling up, 339.
 Method of storing, 339.
- Powdery mildew of the cherry. (See *Podosphaera oxycanthæ*.)
- Puccinia graminis*, 370, 371.
- Pumps, for spraying:
 Barrel force, for eau celeste, 333.
 For spraying cherry trees, 352.
 Nixon, where manufactured, 352.
 Weaver, 363.
- Rose, leaf-spot disease of, 364.
- Rastelia*, 374, 378, 379.
Aurantia, 374, 375, 376, 379.
Botryapiles, 374, 375.
 Characteristics of, 378.
Cornuta, 375.
 Hosts of, 374.
Lacerata, 375, 376, 379.
 On apples, 378.
Pirata, 375, 376, 378.
Transformans, 375, 376, 378.
 Treatment of, 379.
- Rust of:
 Cottonwoods, 390.
 Wheat, 370.
- Septosporium Fuckelii*, 387.
 Compared with American species, 382, 383.
 Described in *Maladies de la vigne*, 382.
- Septosporium heterosporum*:
 Measurements of, 383.
 Original description of, 381.
 Spermogonia of, 382.
 Structure of, 382.
- Septosporium* on grape leaves, 381.
- South Carolina, plum-pockets in, 366.
- South America, origin of potato-rot in, 337.
- Sphaeropsis minima*, 384, 386.
- Spraying machines:
 For Bordeaux mixture, 328.
 Eureka, 323, 363.
 Vermorel, 323, 333.
- Sulphate of copper:
 Effect on *Monilia* spores, 352.
 For mildew, 327.
 Simple solution, formula for, 328.
 Used for black-rot in Arkansas, 332.
- Sulphate of iron:
 For anthracnose, 332.
 For spraying trees affected by *Monilia*, 352.
- Sulphatine:
 Formula for, 327, 328, 330.
 For mildew and rot of the potato, 339.
 For tomato-rot, 340.
- Sulphuret of potassium, 356.
 For brown-rot of cherry, 352.
 For downy mildew of the grape, 333.
 For gooseberry mildew, 359.
 For powdery mildew of the cherry, 356.
 For powdery mildew of the grape, 356.
 For tomato disease, 349.
- Sycamore, disease of, (See *Glæosporium nervisquum*.)
- Taphrina pruni*, 366.
 Bibliography of, 369.
 Botanical characters of, 368.
 External characters of, 367.
 History of, 366.
 Losses from, 368.
 Treatment of, 369.
 Varieties affected by, 368.
- Tests for fungicides, necessity for, 336.
- Time for applying fungicides to grape vines, 327, 328.
- Tomato, a disease of the. (See *Cladosporium fulvum*.)
- Tomato-rot, 339.
- Treatment of:
 Apple rusts, 379.
 Black-rot in Arkansas, 332.
 Brown-rot of the cherry, 356.
 Celery-leaf blight, 399.
 Disease of the sycamore, 389.
 Leaf-blight and cracking of the pear, 362.
 Leaf-rust of cottonwoods, 392.
 Leaf-spot disease of the maple, 386.
 Leaf-spot disease of the rose, 365.
 Plum pockets, 369.
 Potato-rot, 338.
 Powdery mildew of the grape, 333.
 Powdery mildew of the cherry, 352.
 Tomato-rot, 345.
- Uncinula ampelopsidis*, treatment for, 333.
- Uredinea*, 390.
 Abundant in Montana, 326.
- Uredo, 370, 371.
Linearis, 370, 371.
- Uromyces*, 370.
- Ustilago Montaniensis*, 326.
- Vermorel sprayer, 323, 331, 333.
- Virginia:
 Charlottesville, experiments at, 330.
 Special agent in, 326.
 Sycamore disease in, 387.
- Washington, D. C., sycamore disease in, 387.
- Wheat rust, 370.
- Wine, effect of copper mixture on, 332.
- Wisconsin, tomato-rot in, 340.
- Witches-broom, 373.
- Yellows, peach, 392.
- Xyloma mespili*, 358.

